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An Opportunity To Help the Other Fellow

EVERY power plant executive is keenly alive to the coal situation.

Although present exigencies prevent him from being too discriminating as to quality and price, he is, nevertheless, anxious to know how the other fellow is meeting the problem and what he is paying for similar coal.

Unfortunately, the majority of these men have no organization for the exchange of such information. Therefore, *Power* offers its services to this end.

It is hoped that those interested will fill in the blank on the bottom of page two (advertising section) stating the kind of coal, size, source and basis of purchase (whether contract, open market or spot buying), and prices (at mines or delivered), and mail the blank to *Power* at the earliest opportunity.

If sufficient replies are received, the information will be compiled and printed in an early issue. The source of the information will be regarded as confidential.

Remember that in doing this little thing, you are rendering a service to other engineers and power-plant executives.

Steel Foundations for 30,000-Kilowatt Horizontal Turbo-Generators

By J. R. JAMES
Engineer, Detroit Edison Company

The use of combination concrete-steel foundations for large units has been initiated at Detroit. Advantages claimed over an entire concrete structure are greater accessibility within the base, more light, a saving of space, reduced weight, a better disposition of structural strength and mass, with greater facility in correcting for settlements A reduction in weight of about 500 tons was effected, the difference in cost is negligible, and operation has shown almost no perceptible vibration.

ORDINARILY, supports for horizontal turbines are such a commonplace detail that mention of them is not often made. However, the steel foundations for the 30,000-kw. horizontal turbo-generators recently installed by the Detroit Edison Co. present some features worthy of mention.

At the Connors Creek power house three 20,000-kw. machines and one 45,000-kw. unit have concrete foundations, which have not proved altogether satisfactory. From the design point of view the arch in the base over the condenser has been the weak point—both in comparison with the strength of the other parts of the base and in consideration of the unusual forces that it has to resist when a unit "goes bad." Take the 45,000-kw. machine, for example. The rotating elements in the turbine and generator weigh over 100 tons, so that when a bucket fails there is a fairly good imitation of a 100-ton steam hammer making 1,200 blows per minute The arch cannot conveniently be made large enough as a concrete member to resist such force. Burying a steel grillage in the concrete, to encircle the turbine exhaust, while apparently solving the problem, is a questionable expedient, for it seems logical that should a small crack develop, due to any one of numerous causes, small particles of dust or sand would act as fulcrums of forces, which, owing to machine vibrations, are always working to enlarge the crack.

The concrete piers that support the structure directly under the machine base may be looked upon, with regard to reducing horizontal vibrations or movement, as

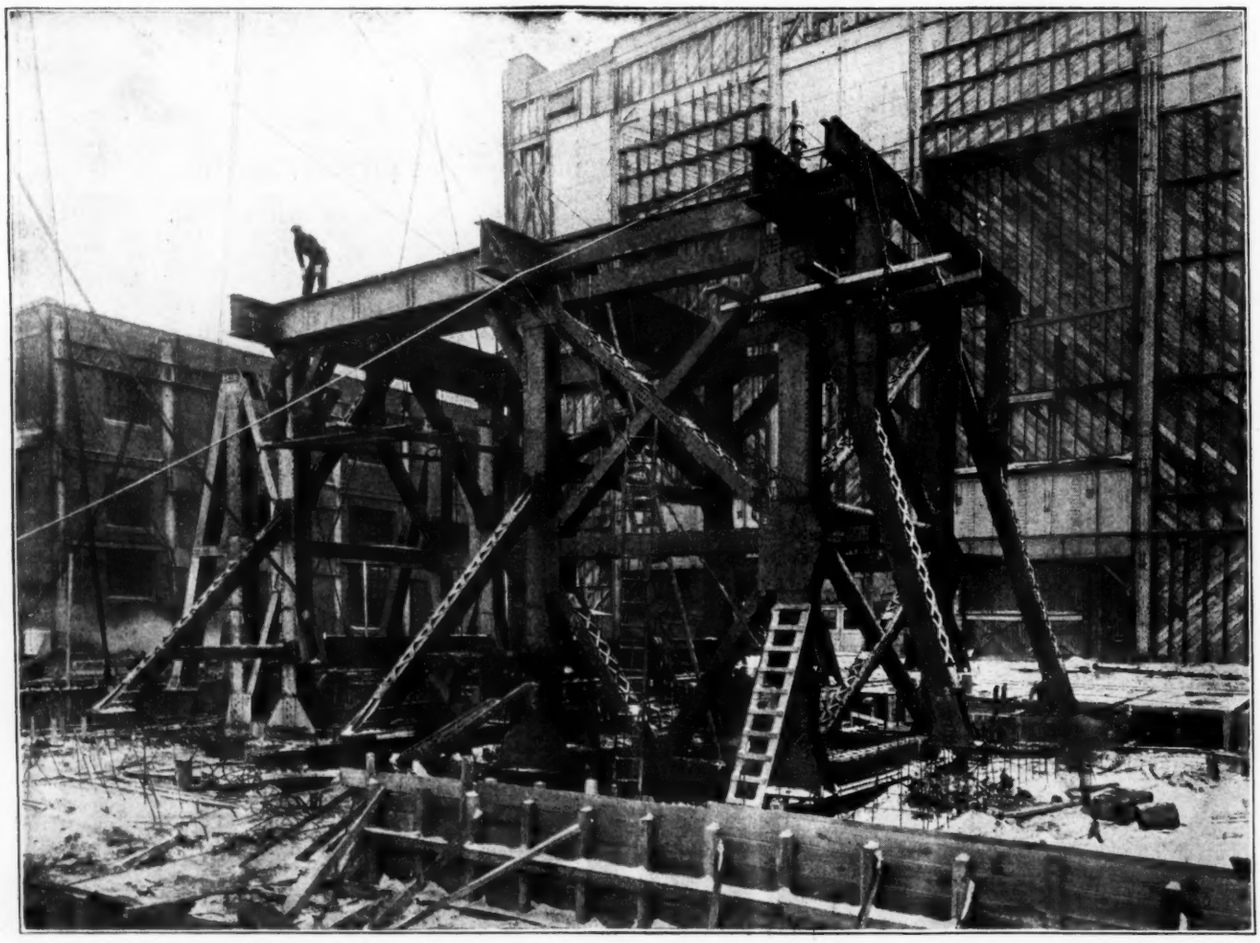


FIG. 1. STEEL BASE FOR 30,000-KW. TURBO-GENERATOR UNDER ERECTION AT CONNORS CREEK STATION

cantilevers with their support at the floor. The great mass of concrete at the floor is therefore used principally to resist an unusually large bending moment when subjected to the severe conditions previously mentioned. For purposes of reducing weight and space, therefore, a steel member at this point would be more efficient. It was such reasoning as this that made a combination concrete-steel structure appear the best suited to fulfill the requirements; namely, greater accessibility within the base, more light, a saving of space, reduced weight, a better disposition of structural strength and mass, with greater facility in correcting for settlements. The reduction of weight was a very important item. For instance, the vertical units in Delray power house No. 2 are to be replaced by horizontal units, and the old mat now supporting the vertical machines would not stand up under a concrete foundation for a 30,000-kw. unit, except with expensive and awkward alterations. The reductions of weight for each of the proposed new units is about 500 tons as between the all-concrete foundation and the composite concrete-steel design.

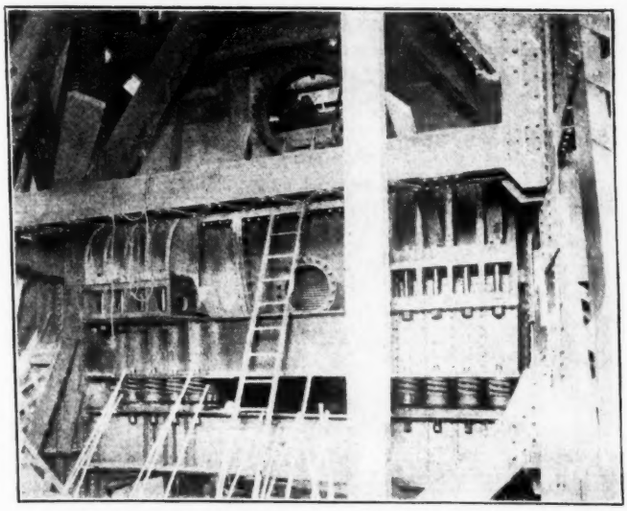


FIG. 2. PROGRESS VIEW AT DELRAY, SHOWING BASE OF CONDENSER

With these points in mind, therefore, a steel design has been worked out with a concrete slab directly under the turbine and resting on top of a steel base. The top of the steelwork is two feet below the turbine-room floor. It was assumed that the nearer the center of gravity of the concrete mass to the base of the machine, the more effective would be this mass in reducing vibration. The concrete was spread out like the top of a table in respect to the steel foundation and separated one inch from the turbine-room floor along its entire perimeter. Its dimensions are 28 ft. wide by 46 ft. 8 in. long, and the top is tiled flush with the turbine floor proper. One strip 5 ft. wide and 47 ft. long on each side of the mass is 4 ft. thick, the remainder of the mass being 2 ft. thick. The total weight is about 350,000 lb. Such a mass will absorb a considerable force before actually getting in motion, and at the same time it lowers the pitch or tune of the structure as a whole so that it is not so likely to vibrate in synchronism with the turbine itself.

After this concrete cap was poured, steel bearings or sole plates were set at short intervals to the intended elevation of the bottom of the turbine base. These sole plates are about 2 in. thick and 2 ft. long by about 10 in. wide. Irregularities in castings were then made up by placing thin shims on these plates, and the entire base was finally grouted in. Sole plates were considered preferable to wedges, as they make a neater job and save time for the erectors.

The problem of providing for settlements must be met whenever a plant is built upon such subsoil as exists at Detroit The entire city is underlaid with a clay bed varying in thickness from about 70 to 130 ft. and quite soft in proximity to the Detroit River. As both the Connors Creek and Delray plants are along the river, foundation types are somewhat limited. A mat or boat foundation was adopted in both cases. With such a foundation a settlement is expected, and the designer endeavors, so far as he is able, to have this settlement uniform over the entire area. The mat at Delray has settled in the shape of a saucer, and as the turbines are set near one edge of the mat, they come on the edge of the saucer and consequently are subject to an uneven settlement. Usually, this settlement is taken care of in the machine by shimming the main bearings, which, as one might well imagine, is an expensive method—especially so if the baseplate has to be regrouted. This means taking the machine entirely apart and starting over again, as with a new installation.

With the new steel foundations, by leaving the bearing plates of each column and brace accessible, it will be a simple matter actually to raise the entire structure by jacks and maintain the top in a level position should any settlement develop. In case of lowering any particular column the shims can be removed (these have been slotted to avoid conflict with anchor bolts) and vice-versa, shims can be added where an elevation is desired.

In the side elevation of the concrete-steel foundation a good idea is given of the proportion of the structure and of the braces at each end of the machine as well as those at the sides. The main columns of the steel base are about 25 ft. long and made up of two 15-in. channels and 18 x ½-in. plate. They rest on a grillage of six 24-in. I-beams about 24 ft. long, which extend transversely to the unit from one colmun to the other. This spreads the load in a satisfactory manner over a large area of the mat foundation proper, which is 4 ft. 6 in. thick. The largest beams used in the structure are 28-in., 165-lb. I-beams. Stresses were computed for 16,000 lb. per sq.in. For live loads, which are composed of the weight of the turbine and the condenser, 50 per cent impact was allowed. No steel framing is used smaller than a section made up of two 8-in. channels. Gusset plates are of ½-in. metal and amply large, as upon these plates depends the rigidity of the structure. Throughout, ⅞-in. rivets are used. The steel in the base and grillages amounts to about 90 tons. With regard to cost the difference in price between an entire concrete structure and the composite type is small; at least that was the situation for this particular job.

At the end and sides of the structure the braces should be efficient in guarding the main part of the steel base against unusual shocks or jolting, such as are experienced when an accident happens to a turbine. On the other hand, there may be danger of getting the structure too rigid. However, with so many riveted connections it is to be expected that there will be some play in the joints, sufficient, in combination with the elastic deformation of the members themselves, to dissipate the force of any sudden shock the structure might meet. At

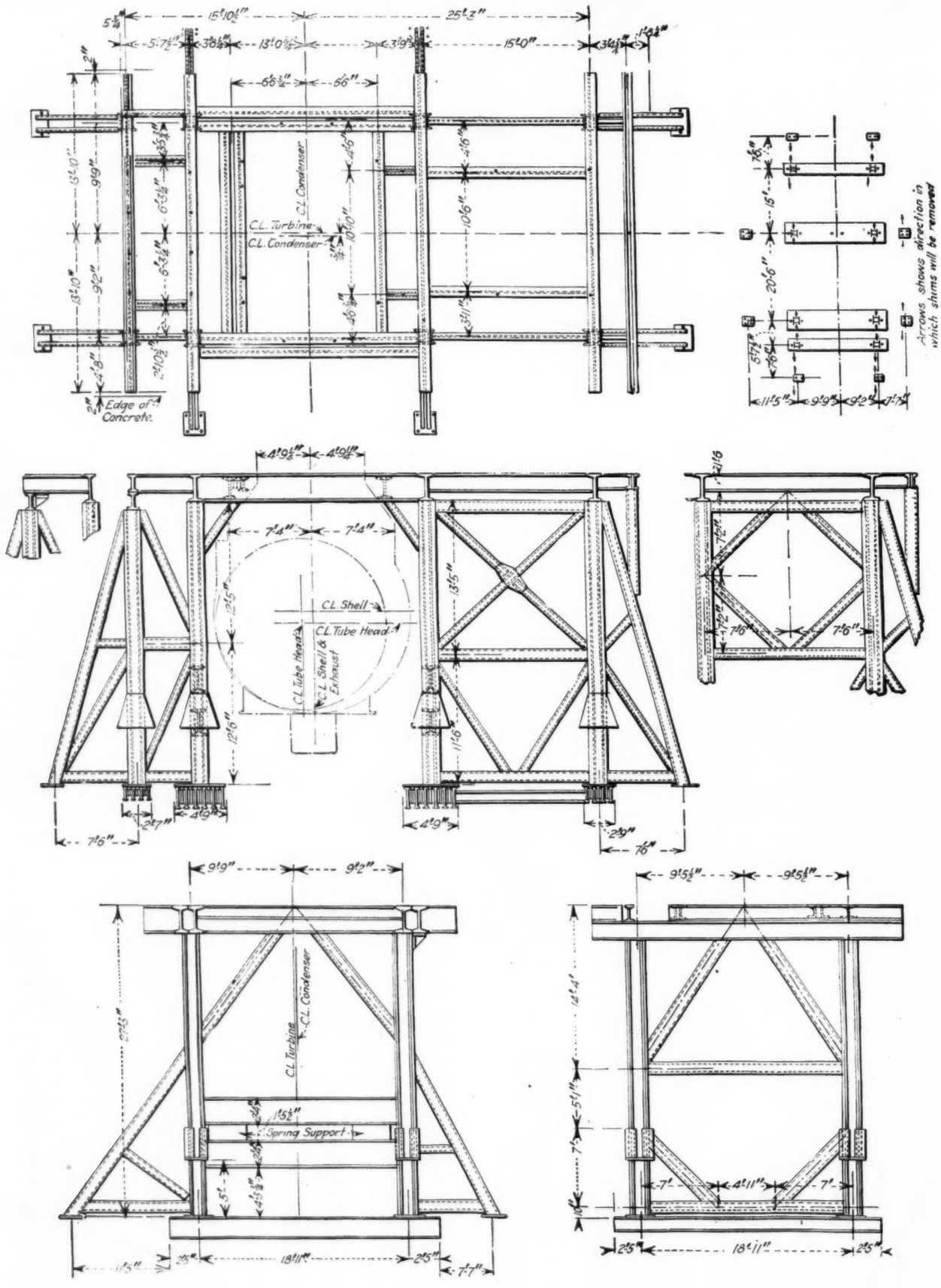


FIG. 3. SHOWING PLAN, ELEVATION AND SECTIONAL VIEWS OF THE STEEL FOUNDATION

least there is a possibility of some "give" to the structure. On the lower part of the columns the "skirts" are made up of plates and angles which are made use of when the structure is to be elevated. A 15-in. I-beam is placed under them and receives the push from a group of jacks.

The reason for the two beams, one over and one under the springs supporting the condenser, is that the condenser heads were transposed, so that the center of gravity no longer would lie midway between the feet of the condenser. Therefore the springs were sandwiched between the two beams in such a position as to take an equal share of the load.

The first of these units has now been operating several months, and its behavior on this foundation has been considered very satisfactory. There is a slight vibration in the end braces on the longitudinal axis. This, however, has not been serious enough to warrant any radical changes. There are several methods available that would probably correct this situation. Possibly, filling the brace with concrete, the additional weight acting as a dampener, or even a rearrangement of the stiffener connecting with the brace, would be the remedy. As an example of how small this vibration is, a tile floor was laid over the exposed concrete cap extending beyond the bedplate of the machine. This tile was successfully laid on a bed of grout 1½ in. thick, while the unit was running with a load of 28,000 kw.

For several weeks the second installation of this type has been operating and is entirely satisfactory. There is almost no perceptible vibration.

Putting the Units in Operation

To discuss the steel type of foundation has been the primary object of this article, but a few words concerning the units themselves, with their auxiliaries, may not be out of place. Such a description would not be complete without a few remarks about the conditions under which they were assembled and put in operation.

A 17-stage impulse turbine, developing 40,000 hp. at 1,800 r.p.m., drives the generator, which has a capacity of 33,333 kva. at 12,200 volts. The turbines are designed for steam at 200 lb. gage pressure at the throttle and 200 deg. superheat. The turbine exhausts into a 42,700-sq.ft. double-pass surface condenser containing 8,490 1-in. tubes 18 ft. long. Circulating water is supplied to the condenser by two 36-in. volute pumps driven by variable-speed motors of 440 to 350 hp. To keep the discharge leg of the condenser less than 24 ft. and so make the siphon effect reliable, the level of the overflow canal was raised by means of a weir.

Vacuum is maintained in the condenser by a two-stage dry-vacuum pump, displacing 2,050 cu.ft. of air per minute and driven by a variable-speed motor. Two wet-vacuum pumps are capable of delivering 1,000 gal. per minute of condensate from the hotwell against 100 ft. head.

Electrically, the unit in the Delray plant is remote controlled, the switchboard being some 1,500 ft. from the power house. Control is effected by a signal panel at each building, safeguarded by two independent telephone lines.

What has made the 30,000-kw. unit in the Delray power house and a similar unit in the Connors Creek station of more than ordianry interest to the Construction Engineering Bureau of the Detroit Edison Co., is the fact that immediate installation was imperative for power requirements. Contrary to expectations after the war, the power load on the system continued to increase instead of diminish, which made it difficult to overhaul machinery that had been pushed to the limit for three years.

To hasten construction on the Delray unit, the condenser was erected first and then the steel base built around it and the concrete cap poured. An excellent spirit of co-operation prevailed between the construction men on the job and the erectors, and as a result the turbine was turned over 37 days after the first carload of machinery entered the yard.

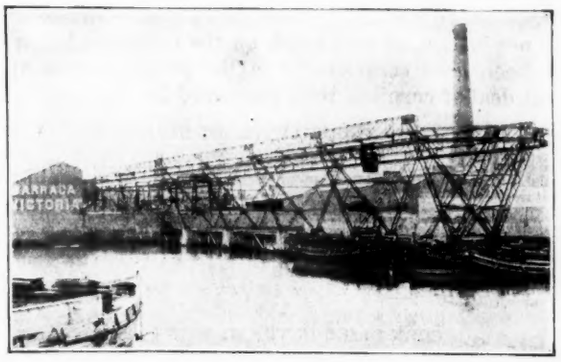
At Connors Creek the unit was installed immediately after the Delray machine. The race for time was even more evident because of a delayed start, due to the breakdown of transportation. The erectors broke their previous record by installing the unit in 30 days, 7 days better than with the first machine.

Fuel in Argentina

By V. L. Havens

The writer lately returned from an extensive visit to South America, and it may be that *Power* readers will be interested in the unusual difficulties that power-house operators have encountered there during the last few years.

The following tables are not for the purpose of indicating exact market values, as the prices changed greatly during any of the late years, but rather to indicate the problem of the power-house executive.



HANDLING COAL IN THE PORT OF BUENOS AIRES

COAL IMPORTS INTO ARGENTINA

Year	Total Imports	From U.S.A	From Great Britain	Approximate Price
1913	4,046,278	56,206	3,977,650	$9
1917	700,000	400,000	300,000	30
1918	821,974	200,000	600,000	50
1919	1,000,000	500,000	500,000	40
1920	.....	.....	.....	35

APPROXIMATE PRICES PER TON OF SUBSTITUTE FUELS, U. S. DOLLAR

	1913	1917	1918	1920
Quebracho colorado wood	$2.50	$10	..	$12
Quebracho blanco wood	2.50	10	..	10
Charcoal	..	..	$50	..
Petroleum	10.00	..	55	..

Quebracho colorado contains a very large percentage of tanning extract. As the name indicates, this is red. Quebracho blanco is used largely for construction purposes as it is practically permanent as a building material. Both are highly valuable woods and difficult to replace, but their use as fuel has become very necessary.

The war has induced the growth of local industry in many ways, and the demand for fuel, especially for

railway use to move the increasing yearly crops, has tended to make the situation more acute. The annual needs of the country may then be assumed to be at least 5,000,000 tons of high-grade fuel for local use and bunkering.

The shortage of three or four million tons has been made up by curtailment of needed power or heat or by the use of wood to a considerable extent, but this has not been the only substitute. Some of the younger power-house superintendents in this country may think they have troubles, but one fifty-kilowatt plant in central Argentine has been running two years on bran and hay. I suppose many an adolescent calf has looked with deep yearning on the fuel pile, but the brave firemen guarded the bins with jealous zeal.

In one of the small gas plants in the state of Entre Rios, in northeastern Argentina, operations have gone on continuously for the last four years with wood gas, enriched after a fashion from such supplies as the local market permitted

Some coal is used in the power houses, supplemented by wood in the larger centers and by wood, corn and bran in the smaller cities, corn, bran and hay in others and, as already noted, bran and hay in a few. The bran is fed with a blower and has produced some extraordinary results, such as scale of glutinous cinder.

On the railways 25 per cent of the fuel was wood in 1913 and 71 per cent in 1916. It is probably higher now. Some interesting facts have been brought out regarding calorific values.

About 2.4 by weight of dry wood, harder than oak, is required to replace the best steam coal. Corn or maize has not been used very much on the railways, but wheat has been used occasionally in the power houses and a great deal of corn has been consumed in this way.

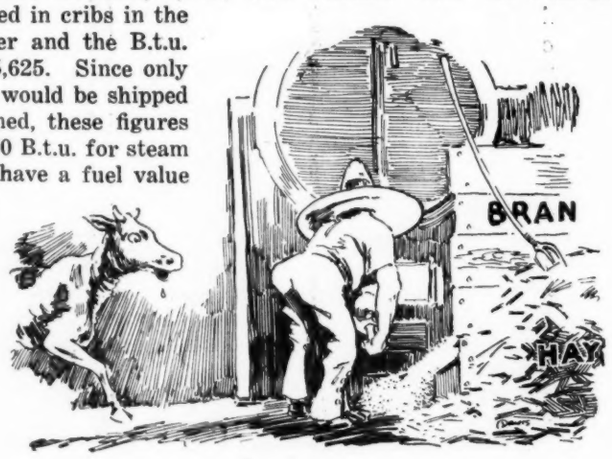
CORN DRIED WITHOUT HUSKS

Shelled corn:	
Total calorific value, calories	3,921
Available after evaporating moisture, calories	3,558
Moisture, per cent	12.6
Corncobs:	
Total calorific value, calories	3,954
Net value, calories	3,747
Moisture, per cent	13.7
Corn on cob:	
Total calorific value, calories	3,930
Net value, calories	3,594

CORN DRIED IN THE HUSK IN CRIBS

Shelled corn:	
Total calorific value, calories	3,755
Net value, calories	3,505
Moisture, per cent	16.4
Corn cobs:	
Total calorific value, calories	3,594
Net value, calories	3,125
Moisture, per cent	18.3

The net B.t.u. per pound for corn dried without husks are: Shelled corn, 6,400; corncobs, 6,745; corn on the cob, 6,470. When dried in cribs in the husk, the moisture is greater and the B.t.u. per pound 6,300; corncobs, 5,625. Since only a high quality of steam coal would be shipped abroad, if it could be obtained, these figures could be compared with 14,000 B.t.u. for steam coal. Then dry corn would have a fuel value of about 0.47 of coal, or to substitute corn for coal would mean handling 2.2 the tonnage. The corresponding relation of cobs to good steam coal would be 0.44 heat value, or 2.3 the tonnage. Corn on the cob is about the same as corn. This is no doubt due to the low specific gravity of cobs as compared with corn, but it would appear that one should burn the corn on the cob if the corn is to be burned at all, thereby saving shelling, getting a better draft and avoiding the minor tendency on the part of the corn to coke.



There appears to be no obvious advantage in thinking of burning corn without the cobs, unless it would be to reduce the space requirements in transportation. This, of course, might prove an important item if transportation should be at all difficult, and anyone considering the use of corn would no doubt consider the details of fuel value obtained per cubic measure as well as weight if they were shipping in barges or box cars.

One Ton of Coal Equivalent to Sixty-Four Bushels of Corn

One could hardly expect such a high grade of coal as the export quality in the average district, but might find a good quality. If the coal normally available is about 13,000 B.t.u. quality, and air-dried husked corn on the cob has 6,740 B.t.u., and taking 70 lb. as a bushel of corn on the cob, then 35 lb. of the coal would be equal in fuel value to a bushel of corn. Likewise a ton of coal weighing 2,240 lb. would have the same fuel value as 64 bushels of corn, and each dollar added to the cost of a ton of coal would add 1.5625 cents to the price of a bushel of corn.

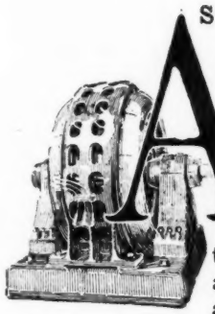
It was not so many years ago, as time runs, that 45 cents a bushel was considered a pretty good price for corn in the farming regions of the United States, especially in the western prairie land. Even then the farmers had to raise cattle and hogs and raise the corn in the neighborhood before they could pay that price. In Argentina corn is raised for export as well as local use. It must be shipped twice as far by sea as corn from North America. Costs of production must generally be lower than in this country. Their railways must charge much higher rates for various reasons. Coal cost nine dollars a ton as a minimum in pre-war days in Buenos Aires. At that time it came out in sailing vessels or as ballast in steamers. The absolute minimum freight was $4. Today the rates are high enough, but no one expects them to get much below $10 for years unless it is as ballast, and that does not control general rates.

It is evident that Buenos Aires will not see coal as low as $20 for many moons, and to that must be added the very high freight rates on coal, hauled with the same expensive fuel or its equivalent, to the interior. Therefore in a region distant from the seaboard, capable of raising good corn at a low cost and having nothing but imported coal, it is not such an extraordinary thing when they even think of raising corn to burn, although the idea may at first seem strange to people in the states. The calorific value of corn as given in the table was determined by the Compañia Alemana Transatlántica, of Buenos Aires. The values are shown in large calories per kilogram of fuel.

Application of Induction Motors—I

General Considerations in the Application of Induction Motors Are Outlined—Kind of Load Motor Is To Drive—Motor Ratings—Required Torque for Starting —Starting Under Severe Conditions—How to Determine Length of Period Required for Acceleration

By FRASER JEFFREY
Electrical Engineer, Allis-Chalmers Manufacturing Company



As a general rule the importance of the correct application of motors is seldom fully appreciated. Outside the lack of proper care and attention, and incorrect installation, it can broadly be stated that at least 95 per cent of all the troubles experienced in the field can be directly attributed to the fact that the question of application was not fully considered at the time the contracts were awarded. The various points that must be brought out to insure correctness of application are surprisingly numerous, and the most important of them are listed here:

1. What is the motor to drive?
2. Kinds of rating.
3. Will the motor have sufficient torque to start its load?
4. If the starting conditions are severe, how much actual torque is required to start the load?
5. What will be the length of time of period of acceleration?
6. If the motor is of the squirrel-cage type, will excessive line current during the starting period be objectionable?
7. Is the capacity of the system supplying the motor sufficient to take care of the starting period?
8. Will the motor operate at its full rated load?
9. Will the motor be subject to heavy overloads and severe mechanical shocks?
10. Will the motor be "plugged"?
11. Location of motor: Floor mounting or ceiling suspension; outdoors or indoors; dry or wet place; explosive gases; acid fumes, clean or dusty; cool or hot; altitude, etc.?
12. Will motor be direct-connected or belted? If direct-connected, how connected to the load? If belted, what is the pulley size on both the motor and the driven machine and the belt centers? Also in what plane will the belts run, horizontally, vertically, etc.?
13. If power is to be bought, will the power demand meet the local power company's requirements?
14. Will the motor and control meet the local underwriters' requirements?
15. Will the motor be supplied with adequate protection such as overload, low-voltage and the necessary interlocking devices?
16. Would some type of machine other than an induction motor or the motor that is selected be more preferable to meet the existing conditions?

There are other features that will naturally come up relative to the existing local conditions, but the main points are as enumerated.

1. What Is the Motor to Drive?

It is generally understood that induction motors are not suited for individual drive of the general line of machine tools, printing presses, etc., and that speed control within close limits is not possible. If speed control is required, then it is necessary to know the exact speed torque characteristics of the driven machine. A squirrel-cage motor is unsuited to accelerate machines having a large amount of inertia such as flywheels, cement- and ore-grinding mills, or centrifugal pumps, fans, compressors, etc., which are not unloaded during the starting period.

Knowing what the motor is to drive gives a check, not only on the suitability of the type selected, but also a general idea as to the possible load conditions to be expected.

2. Kinds of Ratings

The rating of the motor used should correspond as nearly as possible to the nature of the service required. Most induction motors can be classified in respect to the kind of rating under the two general headings—Continuous Rating and Short-Time Rating.

A continuous-rated motor should be capable of delivering its full rated output continuously without exceeding the limitations set by temperature, mechanical strength, dielectric strength, etc. Machines rated under these limitations are suited to conditions where the load is more or less constant and such as is found in almost all of the great industrial and manufacturing plants. Motors having short-time ratings are suited to a service requiring full output for limited periods including runs alternating with stops of sufficient duration to insure substantial cooling without exceeding the limitations as to temperature, mechanical strength, etc. Motors of this class are to be found in the operation of elevators, hoists, etc.

3. Will the Motor Have Sufficient Torque To Start Its Load?

Consider a squirrel-cage induction motor starting a centrifugal pump or fan. The speed-torque characteristics of the centrifugal pump or fan are similar, and the horsepower needed to drive them varies as the cube of the speed, while the torque required varies as the square of the speed. This latter is shown by curve *A*, Fig. 1; the speed-torque curve of an induction motor, for full impressed voltage, is represented by curve *B*, while curve *C* shows the same thing for 50 per cent full impressed voltage, such as might be used for starting the load.

A centrifugal pump with the valve in the discharge line fully open, if started up by a squirrel-cage induction motor on an intermediate tap, will usually not come up to full speed on the starting position, but to some such point as *D*, Fig. 1. If the pump is sustaining a high column of water when the motor is thrown from the running to the starting position, the lapse of even a few seconds of time necessary to change over—that is, temporarily disconnect the motor from the

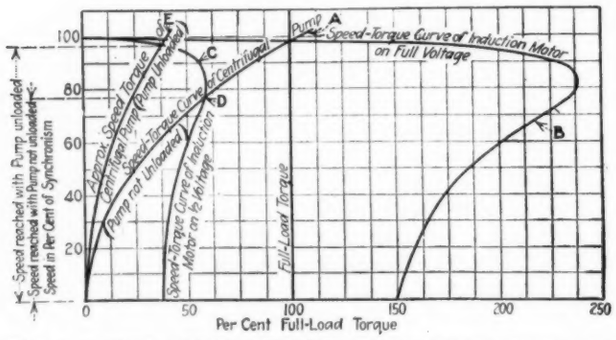

Speed reached with Pump unloaded
Speed reached with Pump not unloaded
Speed in Per Cent of Synchronism
Per Cent Full-Load Torque
Approx. Speed-Torque Curve of Centrifugal Pump (Pump unloaded)
Speed-Torque Curve of Centrifugal Pump (Pump not Unloaded)
Speed-Torque Curve of Induction Motor on Full Voltage
Full-Load Torque
Pump
Speed-Torque Curve of Induction Motor on Full Voltage

FIG. 1. SPEED-TORQUE CURVES OF CENTRIFUGAL PUMP AND SQUIRREL-CAGE TYPE INDUCTION MOTOR

starting and connect to the running position—is sufficient to allow the column of water to start downward. A tremendous shock is created when the motor is suddenly thrown to the full running position, thus tending to change instantly the direction of the water. This shock is severe enough to break the piping in cases where the volume of water is large. It tends to create a severe water hammer, and not only is this hard on the pump and on the motor mechanically, but the electrical jolt is also severe and creates a condition unfavorable to the motor and sometimes to the line.

If, on the other hand, the valve in the discharge line is closed, the torque required at full speed is approximately 40 per cent of the full-load torque and the

CHARACTERISTICS OF SQUIRREL-CAGE TYPE INDUCTION MOTORS

All Motors 440-Volt, 3-Phase, 60-Cycle Squirrel-Cage Type

Hp.	Poles	Synchronous r. p. m.	Full-Load Efficiency	Full-Load Power Factor	Maximum Starting Torque in Per Cent of Normal
150	4	1,800	92 5	93	180
150	6	1,200	92	92	135
150	8	900	91	91	125
150	10	720	91	89	120
150	12	600	90	88	115
150	14	514	90	85	110
150	16	450	90	82	105
150	18	400	89	79	100
150	20	360	87	75	100

motor has no trouble in bringing the pump up to practically full speed on the starting tap. This is shown by curve *E*, Fig. 1, it being assumed that the torque under these conditions also varies as the square of the speed. After this, the discharge valve may be opened gradually and the pump will assume its full load. Under these conditions of starting, the pump must always be filled with water, otherwise the clearance strips are likely to be burned out.

Fig. 2 shows the same starting conditions with a slip-ring type motor. Curve *A* is the speed-torque curve of the pump under full head, while curves *B*, *C*, *D*, etc., are the speed-torque curves of the motor on the different positions of the starter. Such a method of starting eliminates the line disturbance prevalent even with the squirrel-cage motor and unloaded pump and gives a smooth, even acceleration. When the slip-ring motor cannot advantageously be used, it is essential except in the smaller-sized units, that all driven machines such as centrifugal pumps, plunger pumps, fans, blowers, compressors, etc., be unloaded during the starting period when started by squirrel-cage induction motors.

By referring to the table it is seen that as the number of poles of the motor increases, hence the speed decreases, the starting torque for full impressed voltage of the squirrel-cage motor also decreases. This is an inherent feature of the induction motor and is characteristic of all such machines. Slow-speed machines do not have as good characteristics as to power factor, efficiency, torque, etc., as high-speed machines.

Fig. 3 illustrates the difference in the speed-torque curves of two 60-cycle squirrel-cage motors of equal output, voltage, phase and frequency, but of different speeds, one being a 4-pole and the other a 16-pole motor. These curves show that not only the starting torque, but also the maximum torque, is lower on the slow-speed than the high-speed motor. Therefore great care has to be exercised, not alone in the proper selection of the type of motor, but also as to the nature of the starting conditions, in order to make certain that the speed selected assures a motor with the requisite amount of torque.

4. If the Starting Conditions Are Severe, How Much Actual Torque Is Required To Start the Load?

In the correct application of the induction motor, the starting- or static-torque features of the load determine to a large extent the use of the squirrel-cage or

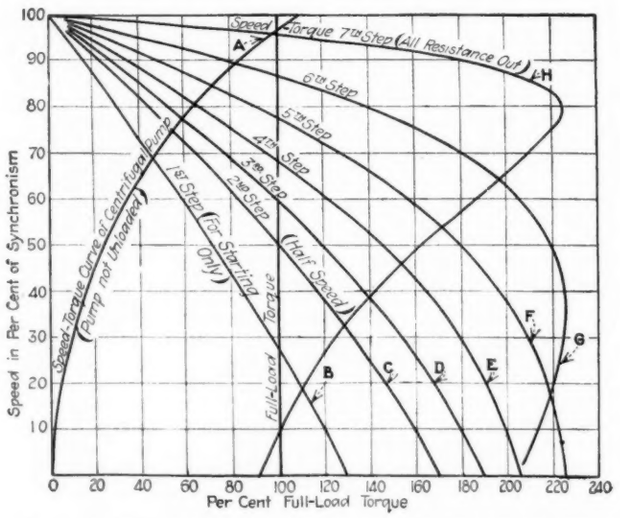


FIG. 2. SPEED-TORQUE CURVES OF CENTRIFUGAL PUMP AND SLIP-RING TYPE INDUCTION MOTOR

the slip-ring type. As a general rule the running-load conditions of any given load are well known, usually by direct measurements of power, but the starting-load conditions are totally unknown.

A good idea as to the static conditions of a load may be obtained by a spring balance used at a known radius. Suppose it were desired to learn the static conditions of a long length of lineshafting in a factory. A spring balance attached to a rope around a pulley

of known diameter or a beam rigidly attached to the shafting will show what is desired. In cases such as this it is always advisable to take a number of readings and under conditions known to be the most unfavorable. For instance, static torque on a lineshaft should be taken, preferably, on a Monday morning before starting up, after the shafting has been idle over Sunday. The readings should also be taken, if possible, at a time when the lowest temperature that is likely to be encountered exists.

When using the beam, Fig. 4, the readings should be taken when the beam is in a horizontal position, then the torque is

$$T = \frac{W \pm w}{16} \times \frac{L}{12}$$

where T is the torque in pounds at 1 ft. radius, L is the length of beam in inches from center of shaft to point of pull of the spring balance, w is the weight in ounces of the beam when free to rotate about the center O (minus when the measurement is made vertically upward and plus when made vertically downward), and W is the weight in ounces read on spring balance for any load.

When the static torque is known, it can readily be transferred into synchronous horsepower by the formula

$$Hp. = \frac{T \times 2\pi \times r.\,p.\,m.}{33{,}000}$$

where T equals torque in pound at 1 ft. radius, $r.p.m.$ equals revolution per minute and $Hp.$ equals horsepower. From this the question of one of the important points of correct application is readily determined. As the motor speed is oftentimes different from the driven-machine speed, care should be exercised in the use of this formula. For instance, consider an arrangement as in Fig. 5, where a lineshaft runs at 400 r.p.m. and the

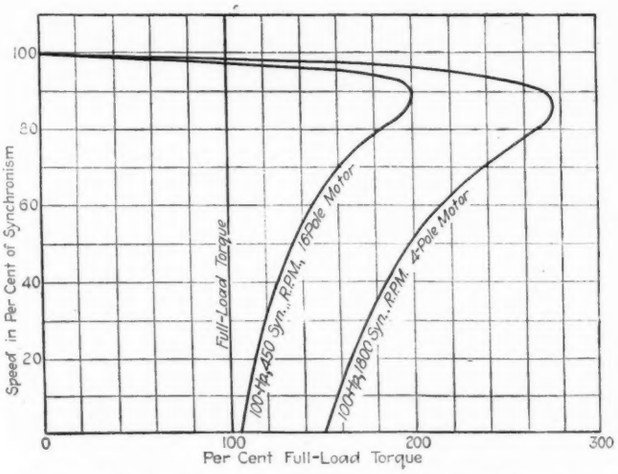


FIG. 3. COMPARISON OF SPEED-TORQUE CURVES OF A HIGH-SPEED AND A LOW-SPEED SQUIRREL-CAGE TYPE INDUCTION MOTOR

motor runs at 1,150 r.p.m. By the use of the beam on the lineshaft the value of T is readily found and the synchronous horsepower is found by the formula for this factor, in which 400 is used for the r.p.m. value. If, on the other hand, the beam is used on the motor shaft, the value of r.p.m. used in the horsepower formula should be 1,150 and not 400. These two methods should closely check each other.

When using a rope around a pulley as in Fig. 6, the torque formula, while practically the same, considers slightly different conditions as follows:

$$T = \frac{W \pm w}{16} \times \frac{L}{12}$$

where L equals length in inches from center line of pulley to center line of rope; w equals weight in ounces of the free length of rope on spring-balance side and

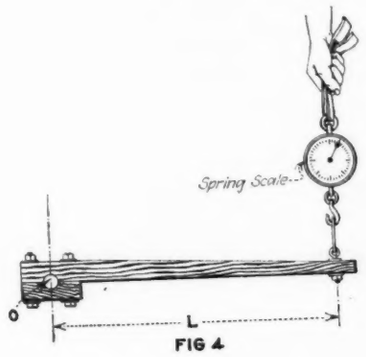


FIG 4

FIG 6

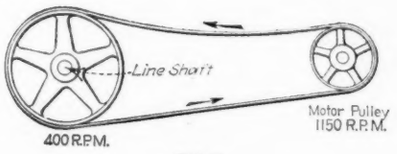


FIG 5

FIGS. 4 TO 6. METHODS OF DETERMINING STATIC TORQUE FOR MOTOR DRIVES

is a plus quantity if the measurements are made in a vertically downward position (if the measurements are made in a vertically upward position, the sign becomes minus); and W equals weight in ounces read on spring balance for any load.

In the case of masses rotated between bearings such as flywheels, motor-generator sets, etc., where the use of the spring balance is frequently not feasible, the power to overcome the bearing friction at the instant of starting may be estimated from the expression,

$$Synchronous\ hp. = 0.3 \times W \times \frac{r}{12} \times \frac{2\pi \times r.\,p.\,m.}{33{,}000}$$

where W is the weight in pounds of rotating parts, r is the radius in inches of shaft in bearings, and $r.p.m.$ is the synchronous speed.

In the foregoing, the coefficient of friction is taken as 0.3, but variations in conditions may make it advisable to change this slightly. The value as given is intended to cover starting under average conditions and not under ideal conditions.

5. What Will Be the Length of Time of Period of Acceleration?

The question of static torque alone is no criterion of what type of motor to use. A flywheel might have a static torque indicating the use of a squirrel-cage motor, but the stored energy necessary to accelerate the wheel might be sufficient to prohibit absolutely the use of such a driving machine. Static torque and period of acceleration must be considered together. On

shafting or machines on which the period of acceleration is in doubt, it is often possible to obtain the necessary data by temporarily connecting a direct-current motor and taking the watts input and time of acceleration. Where such tests are not available, certain data are often obtainable from which a knowledge of the acceleration may be had. Take the following problem:

Problem: Find the power required to start up a shear having a flywheel; where S = speed = 120 r.p.m., D = outside diameter = 11 ft.; W = weight of flywheel rim = 12,000 lb.; and W' = weight of 6 arms of flywheel = 2,250 lb.

Assuming an inside diameter of 8 ft. 6 in. for the rim of the wheel, the moment of inertia,

$$I = \frac{W}{g} \times \tfrac{1}{2}[(r_1)^2 + (r_2)^2]$$

(*Foot-pound-second system of units*)

$$= \frac{12{,}000}{32.2} \times \tfrac{1}{2}[(5.5)^2 + (4.25)^2] = 9{,}000.$$

and

$$(\textit{Radius of gyration})^2 = R^2 = \frac{I}{M} = \frac{9{,}000}{\left(\frac{12{,}000}{32.2}\right)} = 24.1,$$

from which

Radius of gyration $R = \sqrt{24.1} = 4.90$ *ft.* (*say* 5 *feet*)

where r_1 = outside radius of rim in feet; r_2 = inside radius of rim in feet, and g = acceleration due to gravity, equals 32.2.

Therefore, the flywheel effect or WR^2 of the rim equals weight of flywheel rim times radius of gyration squared, in this problem is

$$12{,}000 \times (5)^2 = 300{,}000 \textit{ pound-feet},$$

but the rim WR^2 is also

$$\frac{5{,}870 \times Hp. \times t \times 550}{(120)^2} = 300{,}000 \textit{ pound-feet}$$

therefore the horsepower-seconds is

$$Hp. \times t = \frac{(120)^2 \times 300{,}000}{5{,}870 \times 550} = 1{,}340$$

If the radius of gyration of the flywheel arms is 2 ft. 6 in., then

$$WR^2 = 2{,}250 \times (2.5)^2 = 14{,}050 \textit{ pound-feet}$$

and

$$Hp. \times t = \frac{(120)^2 \times 14{,}050}{5{,}870 \times 550} = 62.7$$

Total horsepower-seconds to bring the flywheel from rest to 120 r.p.m.

$$1{,}340 + 62.7 = 1{,}402.7$$

Assume that the static friction of the shear and the power required to bring it up to speed is equal to one-half that required for the wheel. Then the approximate total accelerating energy is

$$1{,}402 + \frac{1{,}402}{2} = 2{,}103 \textit{ horsepower-seconds}.$$

If the time of acceleration is limited to 20 sec., then the horsepower required is

$$Hp. = \frac{2{,}103}{20} = 105.$$

In the foregoing, the WR^2 of the arms is so small that it could be neglected. It is also seen that a general assumption of power required to bring the shear without the flywheel up to speed also has to be made, nevertheless some idea of the period of acceleration can be obtained. In the case of motor-generator sets, flywheels, etc., where data are not available, some such method of calculation has to be resorted to.

For ordinary calculations the radius of gyration of a rim-type spoke flywheel may be taken as equal to 0.4 × external diameter, or for greater accuracy use $0.707\sqrt{(r_1)^2 + (r_2)^2}$ and the weight of the rim as being approximately 60 per cent of the total weight of the wheel.

For solid-disc flywheels the radius of gyration may be taken as equaling 0.707 × radius, and the calculations for stored energy made as stated, the total weight of the disc having to be considered.

[*This is the first of three articles on induction-motor applications. The next article will deal with items 6 to 10 outlined in this article, and the third installment will take up items 11 to 16 inclusive.*—EDITOR.]

Starting an Old Diesel

In visiting oil-engine plants many Diesels ten to fifteen years old are often encountered. The majority of these old engines have never had a reasonable amount of care. Usually, the pistons are so badly worn that the compression is seldom above 300 lb. per square inch. On starting, the air blows down past the pistons so that it is difficult to turn the engine over fast enough to secure ignition.

Many engineers, not realizing the danger, are in the habit of giving the cylinders a shot of gasoline. The gasoline is poured in through the admission valves. The engine, even though just barely turning over, will fire the gasoline in the firing cylinder. There is grave danger in this procedure. The gasoline will quite likely explode early in the compression stroke. If this occurs, something is going to give way. Even if relief valves are fitted to the cylinder heads, they may fail to open. Frequently, admission valve cages are blown out, connecting rods bent and, to the writer's knowledge, in two instances crankshafts were fractured.

There is no disputing the fact that it is extremely difficult to start a badly worn engine. The best way to do it is to set the air starting valve to open after the piston has passed dead center. This will save a lot of air, since the piston will be moving outward when the air strikes it on the second turn. To prevent too much leakage about the pistons a pint of lubricating oil can be poured in on the top of each piston. The oil will effectually seal the clearance and will raise the compression pressure high enough to ignite the fuel when the fuel valve opens. There is no danger of the lubricating oil preigniting. The engine, even though badly worn, will usually fire.

There are extreme cases of engine wear where even the method outlined above fails to secure results. It is possible to block open the admission valves of the firing cylinders and turn the engines over with the starting cylinder until a fairly high angular velocity is attained. Throwing the admission valve into place at this time will invariably secure regular firing. Of course the proper relief is the reboring of the cylinder and the installation of new pistons. It so happens that occasionally the engineer cannot induce the management to do this. Above all else, no Diesel engine should be dosed with gasoline or kerosene.

Diesel Engines in Cement Mills

Oil Engines Are Proving Economical Power Producers Even in Such Industries as Cement Mills, Where Heretofore Waste-Heat Boiler Plants Have Held the Supremacy

WHEN the Lehigh Portland Cement Co. installed Diesel engines in their Iola, Kansas, plant in 1916, the McIntosh & Seymour units purchased were the first 1,000-hp. Diesels to be constructed in the United States. These 1,000-hp. six-cylinder engines were developed along the same lines as the smaller Diesels built by this firm and so represented no radical ideas in Diesel design. That the design was along sane, conservative lines is attested by the uniform success obtained in the operation of this plant. The plant record of continuity of service is probably unequaled by any other oil-engine station.

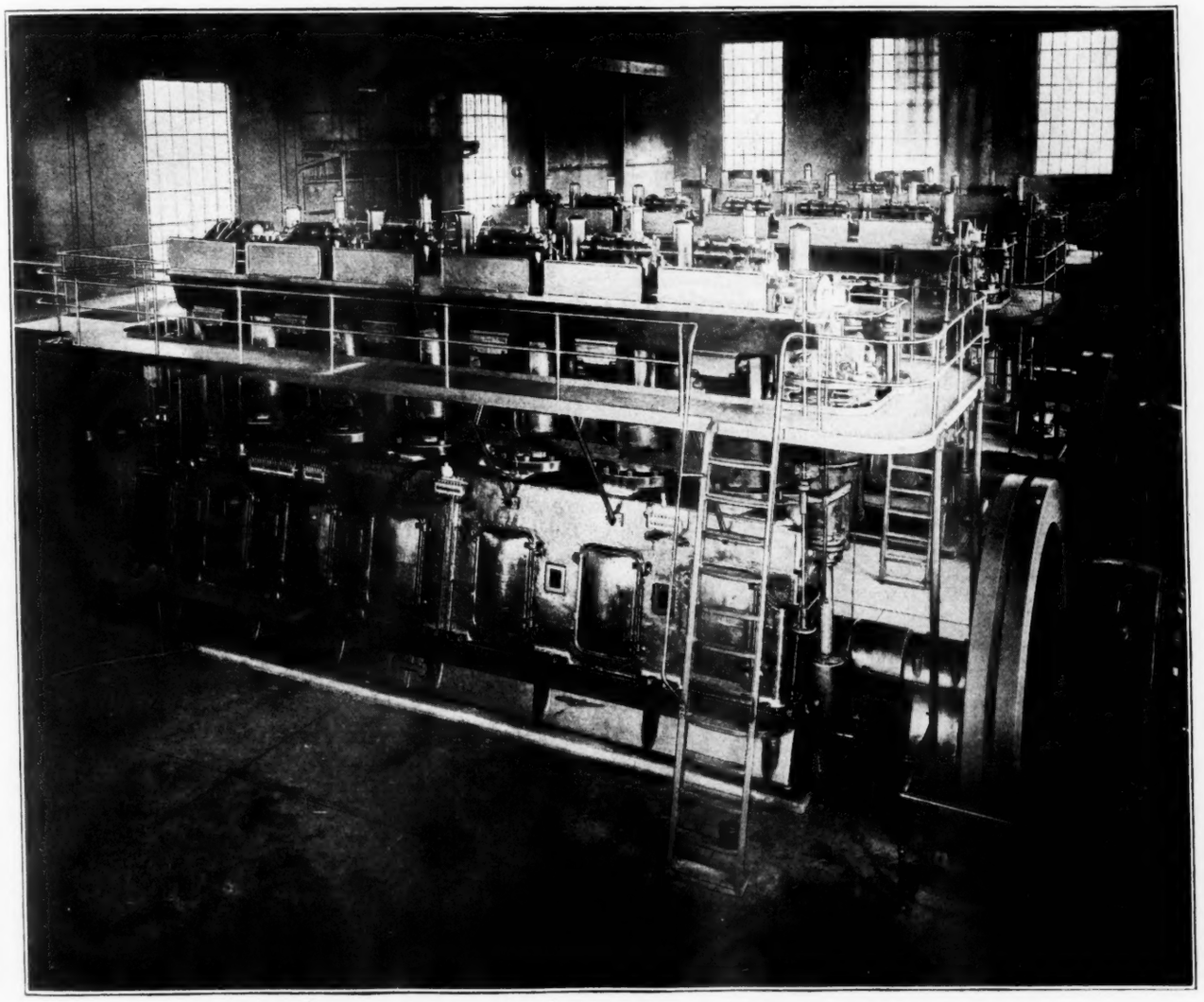


FIG. 1. DIESEL POWER PLANT OF LEHIGH PORTLAND CEMENT CO., IOLA, KANSAS

Originally, three 1,000-hp. engines were installed Each was direct-connected to a 750-kw. Westinghouse direct-current generator delivering 440 volts to the switchboard. In 1919 the fourth engine-generator unit of like capacity was installed, and a fifth engine will probably be in operation by December of this year. The plant will then be the largest Diesel station in America. The units are set in line along the length of the building, as shown in Fig. 1. Space has been left for the fifth engine, the foundation bolts of which appear in Fig. 2 in the foreground. The engine platforms are interconnected, enabling the operators to go from engine to engine without descending to the room floor. The plant is served by a 10-ton Whiting traveling crane. The switchboard is of black slate and is equipped with Westinghouse instruments and switches. The board is set at the end of the building, somewhat out of sight of the operators of all save the adjacent engine.

As has already been mentioned, the record of the plant operation is excellent. One of the units was in constant operation for 417 days, 23 hours and 45 minutes with the exception of a two-hour shutdown at the

end of each six-month period for the purpose of changing valve cages. Since the fourth Diesel has been installed, it is the practice to change exhaust and admission valves every sixty days. The pistons are pulled after six months' service, although the oil shows no tendency toward ring gumming. The only serious trouble occurred when one of the connecting rods was bent, resulting in a fractured cylinder and liner. The

TABLE I—STATION COSTS

Total kilowatt-hour output	1,190,100
Total fuel, gals	112,203
Fuel cost per kilowatt-hour at $0.032 per gal	$0.0030
Labor cost per kilowatt-hour	0.0008
Supplies and oil per kilowatt-hour	0.0015
Total	$0.0053
Fuel oil per kilowatt-hour, lb	0.697
Fuel oil per brake horsepower, lb	0.482

TABLE II—POWER COSTS OF A CEMENT MILL

	Diesel Plant	Gas Engine	Steam Power
Fuel cost	$3,608.44	$2,173.25	.....
Labor cost	1,806.30	622.32	$784.39
Stores cost	956.20	392.16	.....
Total cost	6,370.94	$3,187.73	$784.39
Total power cost			$10,343.06
Total cement, bbl			1,096.86
Power cost per bbl			$0.095

damage was occasioned either by the air-starting valve wedging open or by overpriming of the starting cylinder. If the starting valve failed to seat, starting air at 800 lb. pressure filled the cylinder at the beginning of compression; the connecting rod was not of sufficient strength to withstand the enormous pressure developed as the piston moved upward. The more probable cause was overpriming of the starting cylinder. In the event

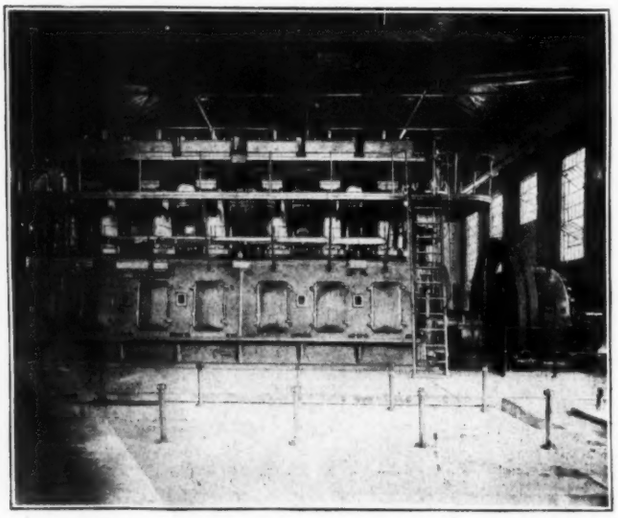


FIG. 2. McINTOSH & SEYMOUR 1,000-HP. DIESEL

that any great amount of fuel is admitted into the starting cylinder, preignition will take place on the compression stroke.

In the way of replacements but few parts have developed faults. Some fifty piston rings have been replaced in the four years' operation. This would average eight years of life per ring. The air-compressor valves tend to leak at frequent intervals. This is not difficult to understand when consideration is given to the location of the plant. The engine room is within a hundred feet of the cement mill. The air for blocks is filled with minute cement particles which settle on the building like flour. The engine room, although of concrete construction, has many doors and open windows. The cement dust fills the air within the engine room and is drawn into the air compressors and the working cylinders. It is remarkable that more trouble is not

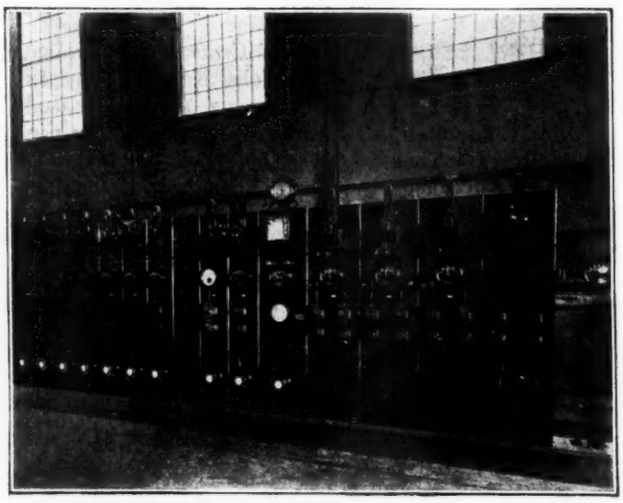


FIG. 3. SWITCHBOARD

experienced. An engine room in such a location should be sealed and all air drawn in through an air washer and filter.

The cost per kilowatt-hour appears in Table I. This covers the operating charges, no fixed charge being tabulated. On a basis of an estimated investment of $600,000 and an overhead charge of 12 per cent, the power costs shown would be increased by 6 mills per kilowatt-hour.

The cement plant also has a gas engine which drives a portion of the mill and a small steam plant for the heating and fire-pump requirements. In Table II are shown the total operating costs of the power plant for January, 1920. The heating and fire-pump costs are shown as totals

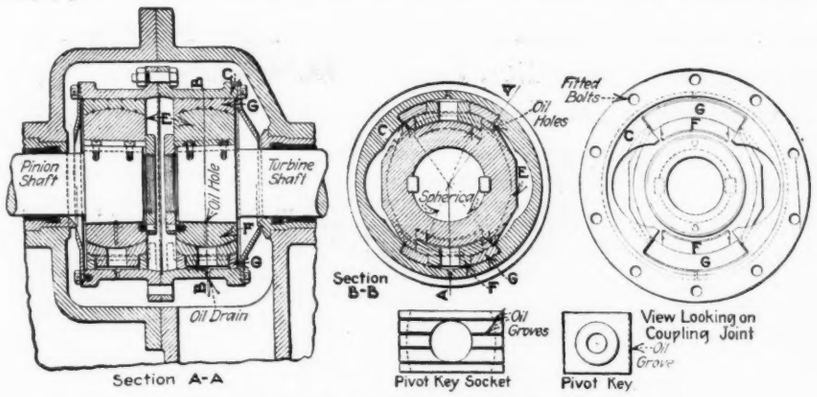
The Robertson-Fairfield Flexible Expansion Coupling

The Robertson-Fairfield coupling was designed primarily for use with geared turbines installed on shipboard.

As reported in *The Engineer*, London, the coupling consists of a casing, or shell, *C* made in halves, which are bolted together when the coupling is assembled. The inner surface of this shell has two gaps, or slots, machined in it, and in these gaps are fitted the blocks *G*, which have been named by the designers "pivot-key sockets," one of which is represented separately. These pivot-key sockets transmit the drive to the casing by coming into contact with the ends of their slots, and at the same time any relative axial motion between the drivers and the driving shaft is provided for by the sliding of these blocks along their slots in the shell *C*. The drive of the turbine shaft is transmitted to the two pivot-key sockets *G* by means of pivot keys *F*, of which one is shown separately; others can be seen in place in the illustrations.

A pin, or boss, which is turned on the convex face of these pivot keys, fits into a corresponding hole

in the pivot-key sockets. The abutting surfaces of the pivot keys and the pivot-key sockets are spherical, as is also the inner face of each pivot key. Each pivot key fits into a slot cut in a block *E* secured to the end of the driving or the driven shaft. These slots are machined to fit the spherical face of the inner surfaces



DETAILS OF FLEXIBLE EXPANSION COUPLING

of the pivot keys. These keys, therefore, can slide over their seats should the coupled shafts get out of alignment, and an angular displacement at right angles to that thus secured is provided for by a slight rotation of the pivot-key sockets on their pins.

The coupling is lubricated by the oil that flows from the adjacent bearings. The oil is caught by the end-plates shown and, after passing between the moving surfaces of the coupling, escapes through small drain holes. The coupling runs drowned in oil, and gutters are machined to the internal parts of the coupling for the purpose of insuring a thorough distribution of the lubricant.

The upper half of the first sketch is a bastard section taken along the radius lettered *A* in the second one. The pressures on the bearing surface are quite definite, being free from the indeterminateness that exists in the case of multiple-claw couplings; as a consequence somewhat higher bearing pressures are permissible, the figures adjusted being from 500 to 750 lb. per square inch.

The coupling is already being applied to geared marine turbines aggregating over 300,000 shaft-horsepower. The working of the patent has been taken over by Michell Bearings, Ltd., of 3, Central Buildings, London, S.W. 1.

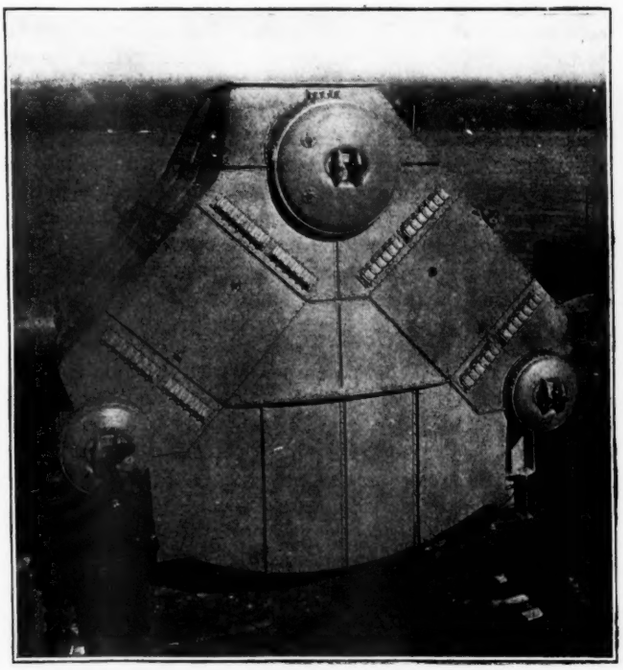
Ludlum Water-Tube Marine Boiler for Naval Experimental Station

The boiler here illustrated, built for the Naval Experimental station at Annapolis, Md., is of special interest because of its large size and the extremely high pressure carried. It is 15 ft. high, 17½ ft. wide and 12 ft. deep, with a furnace of approximately 500 cu.ft. in volume. Its weight is 85,000 lb. complete. It was built for a working steam pressure of 350 lb. and tested to 550 lb. hydraulic pressure. The steam drum is 48 in. by 12 ft., with a tube sheet 1 13/16 in. thick. The water drums are 30 in. by 12 ft., with tube sheets 1 13/16 in. thick. All drums have double butt-strap and double-riveted joints.

The tubes are of cold-drawn seamless steel, No. 10 gage, 1⅞ in. outside diameter. The casing is of No. 10 gage steel plate backed with asbestos millboard and 2 in. of high-tempered special insulating material. The combustion chamber has a 9-in. firebrick lining backed up with the same insulating material. The bottom of the furnace is shaped on the arc of a circle to allow for the proper expansion of the brick lining.

The unit is equipped with cleaning openings for each bank of tubes and also with Ludlum automatic soot blowers, the latter being operated by a chain pull. They automatically dispose of water of condensation in the piping and also shut off the steam automatically after cleaning is completed.

This boiler was too large to be shipped by rail, and it was therefore transported on a barge, completely assembled, as here illustrated. On arrival at the Naval Station it was necessary only to set it on its foundation and connect up the piping and smokestack. No mason work or boiler setting was required. This equipment was built in the shops of the New York Engineering Co. at Yonkers, New York. This company is now at work on a battery of boilers of this same type for the United States



MARINE BOILER DESIGNED FOR 350 POUNDS PRESSURE

Navy, each unit of which will be much larger than the one here described. They will be installed in one of the new battleships now under construction.

Pipe bends for taking up expansion and contraction should be made so that they are shorter face to face than the cold dimension of piping and should be pulled into position.

A large receiver separator pays for itself by delivering dry steam to the engine at a constant pressure, independent of loads.

Maintenance of Welding Machines and Selection of Types To Be Used

Chief Problem of Maintenance Is with Portable-Type Machines—Careful Inspection of Equipment Before Being Put Into Service Is Essential—In the Selection of a Machine, First Cost and Reliability, Electrical Efficiency, Rating and Portability Should Be Considered

By L. W. WEBB
Master Electrician, United States Navy Yard, Norfolk, Virginia

TOO little attention is frequently given to the maintenance of welding machines and equipment, especially those of the portable type. For this reason it is believed that some of the following points can be noted to good advantage.

Where the machines are of the permanently installed type in protected locations such as shops, substations, etc., the usual maintenance procedure can be followed as with ordinary types of motor-generators, etc. This procedure consists principally of seeing that the machine is protected from dirt, dust, water, etc.; that bearings do not heat up, are kept properly filled at all times, and oil renewed or cleaned out systematically; that the commutator is watched and checked to see that the brushes are properly set, fitted and not sparking, and that the commutator is kept cleaned at all times. A periodical visit and inspection by the maintenance man usually suffices to keep the machine in good operating condition, and its upkeep presents nothing unusual and soon becomes a part of the regular shop or plant routine.

Inspection and Working Test of New Machine

With portable-type machines which are being continually shifted from one location to another in all conditions of weather, and for which it is often almost impossible to provide adequate protection against dust and rain, the treatment usually received is very severe, and consequently the maintenance and upkeep of these present problems not common with the ordinary run of electrical equipment, especially permanently installed machines. The following points can be applied to good advantage in connection with these machines:

When the equipment is purchased, and before being put to use and sent out to work, a careful inspection should be made and the machine given a thorough working test in the shop under normal conditions of load, etc., and run for a sufficient length of time to see that bearings do not heat up or other defects exist. If this is a new-type machine, with which the operators have had no previous experience, it is desirable to instruct each operator who may be assigned to it at some future time on its use before it leaves the shop. This will prevent delays at the work which would occur if the operator were assigned with no previous experience in the machine's operation.

When the machine is sent out of the shop to the work, see that all necessary auxiliary equipment, such as welding leads, electrode holders, etc., goes along with it, and is in good condition. This will save any delay in getting the machine connected up and operating after it reaches the work; and if possible all preliminary arrangements as to connections should be made before the machine arrives at the work point.

Instructions for Regulation and Operation

Be sure that proper instructions are issued as to regulation and operation. If possible these instructions should be framed and attached to the machine in a conspicuous place, where they can be easily read yet will be protected from damage. See that the operator thoroughly understands operation before starting him to work if possible to do so, as the extra time spent on this will usually be repaid by better quality and more work produced.

Have the machine at the work point fully protected against dust, rain, etc. Make periodic inspection to see that the bearings are running cool and are properly lubricated.

When the job is finished, and unless another piece of work is immediately available, it is desirable to return the machine and equipment to the shop or central-storage place for inspection, minor repairs and adjustments if necessary, and everything should then be made ready for the next trip. This may look as if too much time were being spent on the machine's upkeep, but where there is available a central-storage space, properly fitted up, only a fraction of an hour need be consumed in doing this and the cost will be negligible. Of course, unless there are several welding machines available it will not be possible to follow this procedure very efficiently, but where there are a number of machines such a practice will prove a great saving. The central storage space, if possible, should be so located that the mechanic detailed to look after it has other routine duties to perform in connection with upkeep and maintenance of other shop or plant equipment. With proper maintenance the machine is always available to send out on a job in first-class operating condition and there is no danger of finding out that something is wrong after arriving at the work and making all preparations to start welding.

Replacement Parts Should Be Kept in Stock

In order to systematize the care and maintenance of these machines and at the same time insure quick repairs or replacements of worn-out or defective parts it is essential that a complete stock of spare replacement parts be kept on hand at all times. To avoid needless expense in this connection, all machines should if possible be of the same type and manufacture, so that the parts of the different machines will be interchangeable. On the basis of two to twelve machines maximum,

the following spare parts can be carried to good advantage: One complete armature (motor, generator and exciter); one complete set of brush holders; two complete sets of bearings; two complete sets of brushes; one field coil of each kind; one set miscellaneous parts on starter and generator panels.

However, since the cost of these parts approaches very closely that of a complete welding set, it is considered more desirable, if possible, to carry an additional machine as a reserve unit and thus always have one ready when trouble happens at the work point. Of course the tendency to use all available equipment at all times makes it very hard to keep a spare unit available and ready when needed and not at use at some other point. For this reason spare parts are often carried as being a cheaper first-cost proposition, as well as an assurance of rapid repairs when all available equipment is being worked.

Some Points That Should Be Considered in Selecting a Machine

In the selection of the type of machine to be used the following points should be considered: (a) First cost and reliability; (b) electrical efficiency; (c) rating; (d) portability; (e) summary for the ideal machine.

(a) Too often machines are purchased because of the low first cost, and this frequently results in finding out later that the extra maintenance required to keep them in first-class working condition and the time lost while repairs are being made make them much more expensive in the long run than higher first-cost machines. Selection on the basis of lowest first cost is usually made through misinformation, but sometimes, unfortunately, through lack of finances. To illustrate the point, assume that ten portable machines are to be purchased and offers of $11,000 and $10,000 are made. Certain purchasers would immediately accept the lower offer of $10,000 and congratulate themselves upon the saving of $1,000, or sufficient to purchase an additional machine, not even considering whether the cheaper machines would in the course of a few years cost more than this amount and possibly require complete renewal. Suppose the higher offer was for machines that could produce 5 per cent more work than those of the lower offer and required very little maintenance? It can be readily seen that under such conditions the higher offer would be the more advantageous to accept. Therefore, the first cost of equipment should be the last consideration in the purchase of machines.

(b) One manufacturer offers a machine of 60 per cent over-all efficiency and another one of 50 per cent. On the basis of electricity at 5c. per kw-hr., 4 kw. output from each machine, we have the cost per hour per machine operation as follows, if figured on normal continuous output rating basis:

(1) $\frac{4 \times 5}{0.60} = 33\frac{1}{3}$ cents per hour.

(2) $\frac{4 \times 5}{0.50} = 40$ cents per hour.

However, the work-duty cycle would not be over 60 per cent of normal rating when due allowance is made for time lost changing electrodes, fatigue of operator, etc. Then the total cost per hour for power on this basis would be:

(1) $33\frac{1}{3} \times 0.60 = 20$ cents.

(2) $40 \times 0.60 = 24$ cents.

This is a difference of only 4c. per hour. Figured on the basis of an eight-hour day and 312 workings days, the yearly difference would be $0.04 \times 8 \times 312 = \$99.84$, which would be a considerable saving if that alone figured in the total cost of operation. Now suppose the other machine, although 10 per cent less efficient, could produce 5 per cent more work; then the comparison for each machine on yearly basis total cost (assuming $1 per hour for operator) would be cost of power, plus operators' pay multiplied by unit of work:

(1) $(0.20 \times 8 \times 312) + (1.00 \times 8 \times 312) \times 1 = \$2,995.20$

(2) $(0.24 \times 8 \times 312) + (1.00 \times 8 \times 312) \times 0.95 = \$2,845.44$

or a difference of $149.76, which more than balances the extra cost of $99.84 for power, as shown in the foregoing. Assuming the cost of work produced to be worth twice the cost of power and labor, the amount would increase to $149.76 \times 2 = \$299.52$, which is a material saving indeed. Therefore it can be seen the electrical efficiency should not be given too serious consideration in the selection of a machine.

Ratings Often Confusing

(c) The rating of a machine is often very incompletely understood. One manufacturer offers a 200-ampere machine that will stand a continuous load of 200 amperes at 25 volts without exceeding safe allowable temperatures. Another offers a 200-ampere machine that will stand a load of 200 amperes at 25 volts for one-half hour, and another offers a machine that is rated for 200 amperes at 25 volts on the basis of current on so many minutes and off so many minutes, or on a so-called welding-duty cycle. The purchaser is often confused, as each manufacturer has offered a machine rated at 200 amperes, while in reality one machine is capable of doing more work than the other.

The one best to purchase under these conditions depends upon the nature of the work and whether the full load capacity of 200 amperes will be required continuously or intermittently.

(d) Portable means capable of being easily carried, and portability, as applied to machines, means those that are easily transported from place to place. The fact that one machine is more compact and self-contained than another, and consequently more portable, does not necessarily mean that it is best adapted for the use intended. Value of portability should be gaged by the ability to get the machine to work points easily, and machines satisfying these conditions meet all the essential requirements of portability.

(e) Summing up the foregoing would show that the ideal machine should be reliable and require very small maintenance expense rather than low first-cost at the expense of reliability and added maintenance. It should have high work efficiency or capacity for producing output rather than high electrical efficiency. It should have continuous-load-duty cycle rating if it will be required to produce work at maximum load conditions for extended periods of time, and should be sufficiently portable so that it can be easily transported to any location desired at a reasonable cost.

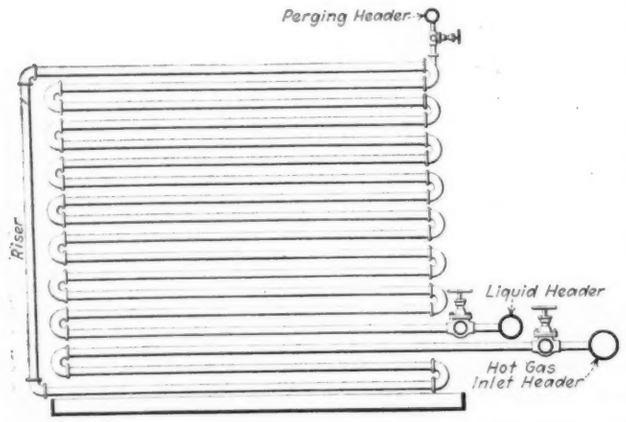
Modern practice tends more and more toward the use of centrifugal pumps in place of the reciprocating type where large quantities of feed water have to be dealt with. The points in their favor are low initial cost, low running cost, small space occupied, light weight and inexpensive foundations, flexibility in operation, smooth running, and they can be direct-coupled to a turbine or high-speed motor.

Ammonia Condensers as the Operating Man Sees Them

By B. E. HILL
Field Refrigerating Engineer with Swift & Company

THERE are a number of types of ammonia condensers, ranging in ratio of lineal feet of 2-in. pipe to tons of refrigeration, to from 20 to 65 ft.; that is, a one-ton condenser of one style may have 20 ft. of 2-in. pipe per ton of refrigeration, while another will have 28 or 30 ft., and still another will be made up with 50 to 65 ft. to take care of the same one-ton machine.

The temperature of the water and the amount available have all to do with the amount of pipe or condensation surface necessary to furnish liquid for the required tonnage and at the same time hold the condensing pressure down to the minimum. The water used for condensing ammonia should be as cold as it is possible to obtain, but as an ample supply is not always available



SEMI-COUNTER-CURRENT AMMONIA CONDENSER

it is up to the engineer or designer of the plant to use what he can get. It may be that to get a suitable and adequate supply of water would be prohibited by cost; or, if not this, it may be that the amount required is not available, in which case a cooling tower would be necessary and the amount of water required would depend on the style or type of tower, locality and weather conditions.

One point must be borne in mind by the engineer with respect to the later types and improvements of ammonia condensers—to cut down on the condensation surface the final temperature of the water must be raised or the volume of water increased.

For example, assume that a condenser having 60 lin.ft. of 2-in. pipe per ton of refrigeration requires 2 gal. of water per minute per ton of refrigeration, with a final rise in temperature of 10 deg. F. Suppose, now, that this condenser was replaced with one of the later types having only 30 lin.ft. of 2-in. pipe per ton of refrigeration to do the same work. The same two gallons per minute per ton would be required on the condenser having 30 ft. as on the one having 60 ft. if the final temperature of 10 deg. F. is assumed in each case. But the volume of water flowing over the surface in the latter case would be twice that in the former, as the surface is but half the former; also, the velocity of gas in the latter is twice that in the former.

To reduce the water supply the final temperature must be raised, the initial temperature reduced, or both, as the water supply to the ammonia condenser must absorb every unit of heat taken out of the products, together with all heat leaks due to opening and closing of cooler doors and radiation. The condensing water is the final heat conveyor which delivers the heat units to the final dump, and if the supply is small, the load of heat units must be heavy, and if the supply is large, the heat load will be less.

The Parallel-Flow Condenser

The old-style "parallel-flow" atmospheric ammonia condenser is made to take the hot gas in at the top pipe and discharge the liquid at the bottom. The cooling water is showered over the pipes from top to bottom, absorbing the heat as it runs over them.

The objection to this type of condenser is that the coldest water is in contact with the hottest gas, and as the water flows down over the pipes, absorbing heat as it goes, the warmest water is in contact with the cool ammonia liquid, which liquid is delivered to the receiver at a temperature ranging from 8 to 10 deg. F. above the final temperature of the water. Now, as this liquid has to be cooled to the temperature of the liquid in the evaporating coils before it can do effective work, there is more or less loss, depending on the boiling point of the liquid in the evaporating coils. The points in favor of these condensers are that the liquid flows *down* and will deliver a steady flow of liquid with no intermittent action, regardless of whether the system is fully charged or not; also, when this type of condenser is used there will be a decrease in condensing pressure when there is a shortage of ammonia, as there is a larger condensing surface than the later types and the condensation medium is all on the outside of the pipes. This old type of ammonia condenser also has the advantage of being nearer foolproof than any other type made; but it is being rapidly replaced with the later types.

If it were possible to use this old-type condenser allowing the hot gas to enter the top and, with a current of air or otherwise, pass a finely atomized quantity of condensing water from the bottom coils up to the top, we would have a condenser that would have all the advantages of the atmospheric type, would use less water per ton of refrigeration and would not require any argument to prove that the liquid ammonia runs up hill without any additional cost, as is the case with all bottom-inlet or so-called flooded condensers.

The Counter-Current Principle

The counter-current principle is to discharge the hot gas into the bottom pipe, where it meets the effect of the warmest water, and as the gas flows upward, the sensible and latent heat is removed, leaving the liquid to be raised a part of the remaining distance by pressure of the incoming gas at the bottom. It is claime

that, owing to the coolest water being delivered at the top where the liquid is leaving, there is a slight reduction of pressure which pulls or lifts the liquid to the top. Some persons go so far as to say that, theoretically, there is a difference in pressure of something like 40 lb. between the inlet and outlet end of the ammonia condenser.

The real counter-current principle is the double-pipe condenser, where the hot ammonia gas enters the top pipe and the liquid ammonia leaves at the bottom, while the cold condensing water enters the bottom pipe and leaves at the top. The objection to this type, however, is that the design is necessarily complicated and expensive; also, it has the disadvantage of not being able to bring the condensation surface in contact with the evaporating effect of the atmosphere.

The Semi-Counter-Current Condenser

Semi-Counter-Current condensers are designed to take the hot gas in the coils at a point ranging from one to five pipes from the bottom. The illustration shows this type of condenser taking the hot gas in at the third pipe from the bottom and circulating the ammonia through these coils first, and at the end of the coil opposite the hot-gas inlet the ammonia is carried to the top pipes through risers and circulated through the top portion of the coils; this liquefies the gas and discharges it into the liquid header, as shown. The object of this type of condenser is to take out the sensible heat, or heat that can be measured with a thermometer, and also to reduce the final temperature of the liquid ammonia leaving the condenser. The bottom three or five pipes are intended to take out the sensible heat only; but in practice there is an accumulation of liquid, which shows that a part of the latent heat is removed also, although this fact does not necessarily mean that *all* the sensible heat is removed, as the liquid will lie in the bottoms of the pipes, allowing the ammonia gas to pass over the top, up through the riser and into the upper part of the condenser to complete the removal of both the remaining sensible and latent heats.

Accumulation of Liquid in Bottom Pipes

The trouble with this type of condenser, especially if the system is not fully charged, is an accumulation of liquid in the bottom three or five pipes until they are filled or partly filled to such an extent that the flow of gas is stopped. When enough of them are filled to a point where the total area is reduced to such an extent that there is a rise in pressure sufficient to force the liquid up through the riser to the upper part of the condenser, then the same process starts all over again in the same or some other set of coils.

The coils that are filling with liquid can be detected by inspection of the risers, which will cool off considerably below the temperature of the coils that are working, all of which can be easily detected by touch. While inspection is being made, a chalk mark is placed on the cold risers. It will be found after an hour or two that all or a part of the marked risers will be warm and working well and that another set or other sets will be cold, which is caused by liquid filling in and stopping the flow, as already explained.

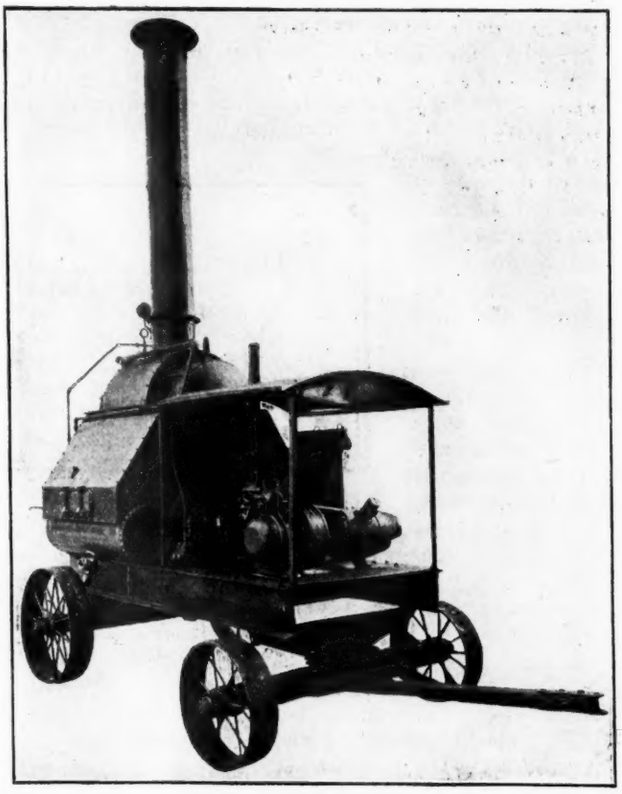
This intermittent or irregular supply of liquid ammonia causes a "long" supply one minute and a short supply the next, which is sure to make more or less trouble with temperatures. The only right and proper thing to do in this, or in any any other case for that matter, is to keep the system charged to the limit so that the receiver will not run dry of its irregular supply from one charge to the next.

The supply can be made to flow through these types of condensers a little more regularly by partly closing the inlet valves to each coil on the hot gas header, but the writer would not advise this being done unless at a time when the suction pressure is at the maximum, and then it should be carefully watched.

Ludlum Dynamobile

This new mobile power unit was designed and built by the New York Engineering Co., 2 Rector St., New York City, for driving the small portable conveyors used in certain classes of mining in South Africa.

The dynamobile consists of a special type of Ludlum water-tube marine boiler, a steam turbo-generator unit, switchboard, boiler-feed pump, feed-water heater, condenser and, where the highest economy is sought, a superheater—all mounted on a steel frame carried on wheels. It is simple in construction and operation.



NEW MOBILE POWER UNIT

The outfit can be furnished for burning any kind of fuel. The combustion chamber is surrounded by the water-filled steam-generating parts of the boiler, thus doing away with all firebrick lining—a good feature, as transportation over rough roads would break or dislodge in firebrick furnace lining.

The high efficiency of the boiler and turbo-generator set and its compactness and light weight make the Dynamobile a most economical and desirable unit for portable power purposes, as it can be located near its source of fuel and its power electrically transmitted to any reasonable distance with minimum loss.

The outfit illustrated is of 10-kw. capacity, but larger units up to 200-kw. are furnished.

The Air Compressor in the Power Plant—II

By SNOWDON B. REDFIELD
Engineer-in-Charge, Engineering Department, Ingersoll-Rand Company, Easton, Pennsylvania

ALTHOUGH the fact is not always appreciated, it is true that the building of a high-grade air compressor is just as much of an art as the building of a steam engine or turbine. In fact, the compressor builder has a far wider range of variables than the builder of engines and turbines; the latter has but a limited range of pressures, superheats and vacuums, and he usually aims to develop a certain limited range of mean effective pressures, while the compressor builder's pressures alone range from the highest vacuum obtainable by a dry vacuum pump to as high as 4,000 lb. per sq.in. Also, compressors are built not only for air, but for gases—natural gas, city gas, oxygen, acetylene, hydrogen, nitrous oxide, carbon dioxide, sulphur dioxide and ammonia—and there are many hundreds of compressors used for the purpose of "squeezing" out gasoline from the casinghead gas of oil wells.

Just as the builders of high-grade engines and turbines strive to turn out a machine that will do the most work for the least expenditure of steam, so the compressor builder aims to produce a machine that will compress the most air or gas for the least expenditure of power. When standard compressor units run into the thousands of horsepower each, it will be appreciated that ecomony is highly essential. Such considerations lead to various refinements of valve mechanism, single-stage, two-stage and three- and four-stage compression, with highly efficient cooling devices in cylinder walls, and especially between stages of compression.

It is always best to follow the builders' drawings when installing compressors. The latest compressors use the plate and feather types of valves instead of the Corliss type formerly used. Belted compressors are more common than gear-driven. Accumulated carbon should regularly be cleaned from the valves to avoid leakage. Defective valves are invariably hotter than sound valves when the compressor is in operation and therefore easy to detect.

In cases of new installation the foundation and piping schemes must, of course, be planned ahead of time. The builders furnish plans that show foundation and pipe connections for steam, air and water, and it is always well to follow these as closely as possible because they are based upon thought and experience with this class of machinery. Of course the ground for the foundation must be firm, or else the foundation extra deep.

Different Types of Steam-Valve Gear

In the past, when rotative speeds were lower than they are today, the Corliss steam-valve gear was considered the best for highly economical steam-driven compressors. This type is so well-known and understood by power-plant engineers that it needs only to be mentioned here. In these machines the air-pressure governor changes the cutoff to control the speed and air quantity. The governor may control only the high-pressure side of a compound engine or it may control both cylinders. In the former case the steam-receiver pressure will change with the cutoff and so the proportion of load will vary between the two cylinders. In the latter case the steam-receiver pressure will remain constant and so will the division of load.

In an air compressor the mean effective pressure in the cylinders remains so nearly constant throughout a wide range of speeds that there is but slight difference of cutoff from full speed to slow speed, so that the refinement of having the governor control the cutoff in both steam cylinders of a compound unit is not usually resorted to. The low-pressure cutoff is generally adjustable by hand to secure a proper average steam-receiver pressure and distribution of load.

It should be needless to say that with a Corliss steam gear the throttle should be wide open while running, to secure economy. Observation, however, reveals that too often this practice is not followed.

Another form of steam-valve gear which was quite universally popular fifteen years ago was the Meyer cutoff. As mentioned, the mean effective pressure is so nearly constant in an air compressor that this form of cutoff could be used to secure good economy, for when the valve was once properly set it needed little adjustment. The fact was, however, that it was so much easier to start a compressor with a long cutoff, few operators took the trouble to adjust the valve to short cutoff. The result was that the Meyer cutoff was more of a "selling point" than one of practical value.

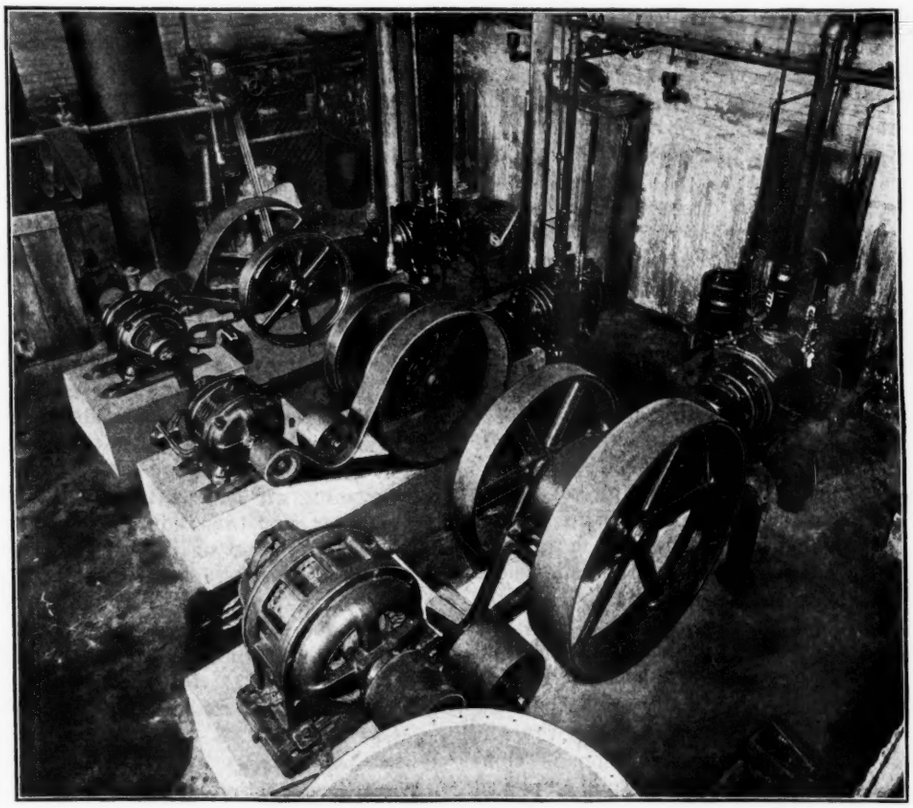
Since the day of the Meyer valve there have been designed some compressors that really do obtain the high economy of the short cutoff. These machines use the well-known balanced piston valve, and some are single valves controlled by a flywheel governor, similar to the automatic cutoff, high-speed steam engine, while others employ the Meyer principle of a concentric cutoff valve within the hollow main piston valve. The cutoff valve is then under the direct control of the air governor and the obtaining of the high economy of the short cutoff does not depend upon the necessity of adjusting the rider valve by hand. The action is then just as automatic as a Corliss gear, with the added advantage of higher speeds and ability to use higher superheats.

With the former type a 75-hp. unit running on 100 lb. steam pressure, non-condensing, may have a steam consumption one-fourth less than the ordinary throttle governor and fixed cutoff. With the more elaborate form having Meyer cutoff controlled automatically by the air pressure, steam economies equal to Corliss steam gear are attained and sometimes exceeded.

With any of these machines employing governor-controlled automatic cutoff, it is essential to economy that the compressor be run with throttle wide open. For electric-driven small compressors the belted unit

is most usual. Gear drives are not so universally satisfactory for compressors, no doubt because of the uneven turning moment; as an improvement upon the disadvantages of gear drive some compressors are regularly built with a belt idler attachment. By this means the compressor and motor may be set almost as close together as if they were gear-connected and yet not have the troubles and noise of gearing. At the same time the idler enables much greater belt contact surface to be obtained and so makes it possible to cut down belt tension, with its attendant bearing friction and wear.

For larger electric-driven units the motor is usually mounted directly upon the compressor shaft in the same manner as engine-generator units. With these machines it usually is customary to furnish a synchronous motor. Such a device may be adjusted by over-excitation so as to improve the power factor of the electric line, which is most desirable. By adding a good-sized synchronous motor of this type to an electric system, less generator capacity may be required than with any other type, and also a cheaper unit rate for current often is obtainable from power companies. In purchasing such a unit, it should be determined in advance whether or not it is to act as a "rotary condenser" of this sort, and the purchase should be made accordingly. This is a study for the electrical men of the plant. If, however, the machine is simply to run at "unity power factor," the exciter rheostat is adjusted until the compressor motor draws the least main-line current.



BELT-DRIVEN AIR COMPRESSORS USING IDLERS

The synchronous motors furnished on these direct-connected units are of the self-starting type. The windings are so arranged that under light torque the motor will start as an induction motor and when at nearly full speed the throwing of the exciter switch puts it into "step" and the motor then operates in synchronism with the generators.

To start with light torque, some form of starting unloader must be provided. After having turned on the cooling water in preparing to start the compressor, it is important to see that this regulator is set in the light-load position before throwing the switch. If this is not done, either the circuit breaker will be thrown open or some injury may be done to the motor.

In the high-economy compressor the type of air valve used plays a most important part. A few years ago most air-compressing cylinders were provided with Corliss or, rather, rotary air valves moved by eccentrics, and usually the discharge valves were of the poppet type.

With valves of this kind the rotative speed of the compressor was limited, not only on account of the excessive noise of the poppet valves, but the valves being relatively heavy, the severe pounding they received made them specially liable to breakage. Also, the speed at which the rocking Corliss inlet valves could be operated was limited, as the inertia of the valve parts and the consequent strains on the parts became quite severe, especially when acute angles were employed in order to get quick opening movements. Since the best days of poppet and Corliss air valves there is a marked preference among practically all compressor builders to use some form of so-called "plate valve." These are of many kinds, being made out of thin plates of steel. Some are circular one-piece perforated plates, some are strips, and some are in the form of rings. All these valves are assembled to some form of seat which is put into the cylinder casting and held there by bolts.

The advantages of plate valves are principally the ability to run at high rotative speed, absence of noise and especially economy of power. The high rotative speed not only gives large capacity from a machine of a given size, but also means a much cheaper motor for a given horsepower when of the direct-connected, shaft-mounted kind. Absence of noise is of secondary importance, but is much appreciated by the operators in the power house, while the saving in driving power per cubic foot of actual air delivered, which is quite material, is a feature that appeals strongly to the man who is responsible for the coal or power bill.

In these plate valves the form of guide to the moving plate is an important matter affecting wear, and with it, tightness against leakage. To insure tightness, it is essential that the side play of the valve

should be a minimum, so that it will always seat in the same place. The metal surfaces of the seat and of the valve then become exactly fitted to each other by the continued pounding in the same spot. To secure this condition the plate valves furnished by the Ingersoll-Rand Co. are guided, not by sliding on lugs or pins, but by the flexibility of the valve itself, part of the flexible arms being bolted directly to the seat. Thus the guiding and absence of side play cannot be affected by the wear of any sliding parts.

Valves of the plate type are also automatic in their action, being operated only by the air. Thus they are free from the possibility of wrong setting, which may occur with a mechanically moved or Corliss inlet valve.

This brings to mind an erroneous idea which was sometimes taken to indicate high volumetric efficiency. Every air cylinder must have some clearance or waste volume between the piston and cylinder head and under the valves, and at the beginning of the suction stroke this air must expand. If allowed to expand completely before the inlet valve is opened, it will do useful work upon the piston and assist in the driving. This may be shown by the re-expansion on curves of indicator diagrams. If, however, the inlet valves are made to open at the beginning of the suction stroke, this air trapped in the clearance space will simply "puff" out to atmosphere and the useful work that it might have performed is lost.

Effect of Premature Opening of Inlet Valves

The effect of this premature opening of the inlet valves will be to show a perpendicular drop in the line of the indicator diagram, and as this has been sometimes erroneously taken to show that the clearance is small and so the quantity of air trapped therein small also, it has been claimed that it showed high volumetric efficiency. As a matter of fact, the amount of air trapped in the clearance space, instead of being discharged, is exactly the same whether the clearance air is allowed to expand or not, so this premature opening of the inlet valves not only does not truly show more air handled, but it also is a direct waste of power in not giving up its useful energy by being allowed to expand behind and help the piston.

With plate valves automatically operated by the air, they cannot open until clearance expansion is completed, so that the energy of the air is usefully employed in assisting the piston during this part of the stroke.

In the care of air valves it is good practice to inspect and clean off the accumulated carbon at regular intervals. Carbon may cause leakage, and leakage certainly causes carbon. A leaking valve becomes hot from the passage of the heated air back through it, and this heat forms carbon from the lubricating oil. This carbon in turn may make worse leakage and worse heat, resulting in an overheated and warped valve, which becomes worse with continued use.

Valve trouble may be located in several ways. In a compound compressor, if any of the low-pressure valves are out of order, the intercooler pressure will be below normal because the low-pressure cylinder will not be furnishing enough air to keep the intercooler pressure up to what it should be. Trouble with valves in the high-pressure cylinder will be indicated by a rise in intercooler pressure above normal. This is because the high-pressure cylinder will not be taking the air away from the intercooler fast enough to prevent the abnormal building up of the pressure.

The foregoing statements as to the effect of the valves upon intercooler pressure apply equally well to inlet or discharge valves. Any particular defective valve may be located by its being hotter than the others. This is especially true of the intake valves.

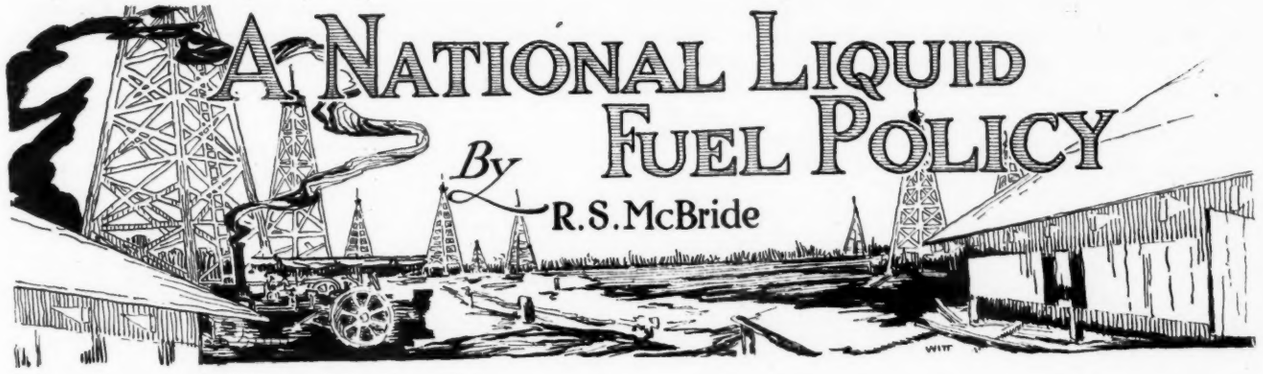
Measurement of Compressed Air

Mention should be made that at present it is possible to measure compressed air by means of a nozzle. The only difficulty is that during the measurement, if accurate figures are to be obtained, the air must be discharged to atmosphere.

In this measurement the compressor discharges at its rated pressure into the main air receiver. From here the air is bled through a globe valve into a second receiver, in which is a nozzle of such size that it will pass all the air from the compressor at a pressure not greatly exceeding atmospheric. This pressure may be obtained with a water or mercury column, and knowing the temperature of the flowing air and the barometer reading, the flow may be calculated. By using a nozzle with a well-rounded entrance, the friction and eddy losses are so slight that the actual flow is within one or two per cent of the theoretical. This has been proved experimentally many times and has become a standard method of measuring air flow. Many engineers' handbooks give the formulas by which the air quantity may be calculated.

The old method of estimating the volumetric efficiency of a compressor by measuring the length of the intake line shown by the indicator diagram has now been discarded as inaccurate and deceiving. This method assumes that the air shown to be in the cylinder is at intake temperature and that there is neither piston nor valve leakage. With some types of machine the incoming air is greatly heated before getting into the cylinder, and this reduces the actual amount of air delivered to the work in the same way as described under the subject of "intake duct." The loss from these sources may cause the actual delivery of the compressor to be from 3 to 15 per cent less than the so-called "indicator-card volumetric efficiency" would show. This loss is vitally connected with the design of the compressor and is therefore a most important point.

Work in connection with the Aura power station, Norway, was begun in April, 1914. Many difficulties were encountered during the years of war, and work was finally stopped, but is now to be resumed, according to *The Electrical Review*, London. It was originally estimated that the whole of the Aura works would involve an expenditure of 38,000,000 kroner ($9,500,000). The idea was first to utilize the Lilledal watercourse so as to obtain 90,000 hp. by the end of 1921, and to increase this power to 300,000 hp. by the further use of the Aura River. So far, however, only one-third of the work is well under way and this has required 20,000,000 kroner ($5,000,000). The first installment, which is to develop 44,000 hp., is not yet completed, and additional capital is required for the purpose. In the case of the Ranasfoss, the work is progressing rapidly and is expected to be finished next autumn. This fall is to develop 72,000 hp.; 15,000,000 kroner ($3,750,000) has already been expended on the development, which is to be completed at a cost of 41,000,000 ($10,250,000) as contrasted with the original estimate of 18,000,000 kroner ($4,500,000).



A National Liquid Fuel Policy

By R. S. McBride

How Can the Maximum Petroleum Production and Delivery to Market Be Secured? What Substitutes or Supplements in Liquid-Fuel Supply Can Be Produced and in What Quantities? How Can the Available Supplies Be Best Distributed Among the Various Classes of Users When the Total Demand Exceeds the Available Supplies?

ONE day we read of the curtailment of Mexican oil supplies by a new revolution and the domination of the world petroleum markets by Great Britain. The next day we read that the petroleum interests in Mexico are to be fully protected by the provisional government and that Great Britain would not think of interfering with United States petroleum development or attempt any of the unreasonable things which are charged. As a consequence there has been a most uncertain state of mind developed with respect to the imminence of the liquid-fuel shortages which we know must ultimately confront this country. It is not worth while to speculate as to the merit of these claims as to Great Britain, Mexico, Persia or any of the rest, for at best it would be speculation. It *is* worth while, however, to raise the more important question, What is going to be the policy of the United States with respect to the future of liquid fuels?

When the need of a national policy is suggested, it is not meant that the Government should enter the petroleum business to direct or interfere. The industry must serve itself, but it must do this along national lines and intelligently. Paternalism is not a successful stimulant; it is rather a prop for weak industries.

Factors That Must Be Considered

The needed national policy must consider three things: (1) How can we secure the maximum petroleum production and delivery to markets and what will this maximum be? (2) What substitutes or supplements in liquid-fuel supply can be produced, and in what quantities? (3) How can the available supplies be best distributed among the various classes of users, when the total demand exceeds the available supply?

These three questions would each justify extended discussion, but here they can be treated only briefly to show the need of further consideration on a broad basis.

One need not worry as to details or exact figures regarding petroleum resources or consumption of the next few years. It makes little difference, indeed, as to whose figures or interpretation of figures is used; there are at least three outstanding facts that are undisputed: (1) The United States still produces more than half of the oil marketed in the world, (2) at the same time it uses about 80 per cent of the world's output, and (3) it has approximately 10 to 15 per cent of the total known oil reserves of the world. These three facts are generally accepted, and almost any interpreter of them will agree that we are as prodigal in this line as elsewhere and have rapidly built up so-called "essential" uses beyond our means of supply.

We can accept any of the several estimates of petroleum reserves, and then may use any particular system of estimating the rate at which consumption is going to increase, either gradually or by continually progressing steps as in the past, and we have the same result. The best we can make of the situation when production and consumption figures are set side by side is to admit that with petroleum alone we cannot maintain the present pace. David White in a recent statement summarizes the situation as follows:

> The recoverable oil in this country, according to the conservative estimate, would probably be practically exhausted in 17 years if the 1919 rate (nearly 380 million barrels) of production could be maintained for so long, while a reserve of seven billion barrels, at moderately liberal estimates, would disappear in 18½ years.

Whether we agree with this part of his statement exactly or not, we cannot deny his later statement as follows:

> The production of natural petroleum in the United States must pass its peak at an early date—probably within five years and possibly within three years—though the long sagging production curve may be carried out beyond the century. . . . The output of oil in 1919 could only with great difficulty be made to increase abreast of the increase of consumption in 1919, and that possibly within three years and very probably within seven years, the production of this country would pass its climax, notwithstanding the growing deficiency as compared with the needs of the country.

Even the most sanguine, therefore, will have to agree that we are doomed either to reduce our liquid-fuel consumption or to seek new sources.

Supplementary Supplies and Substitutes

The second question in national policy demands consideration of the substitutes and supplementary supplies of liquid fuel. Most discussions of this subject have given principal consideration to only one or two of the several possibilities. As a matter of fact all means for supplementing existing liquid-fuel supplies are needed. Even taken all together, they are not enough to really satisfy the total liquid-fuel demands of the country.

The most obvious means of augmenting liquid-fuel supplies is, of course, increasing domestic production. An increasing import of foreign production, or what is equivalent, a decreasing export would work to the same end. The less obvious but equally effective method of increasing the efficiency of use, thereby decreasing demand, also requires consideration. These three considerations taken together afford the major means of supplementing the petroleum supply.

The question of substitutes is, however, quite a different one. Shale oil will in time become available in tremendous quantities in this country. It has afforded, therefore, a basis for the most spectacular prophecy of new resources to substitute for petroleum. Alcohol and benzol from sources such as fermentation, coking of coal and others offer promise on a smaller scale as

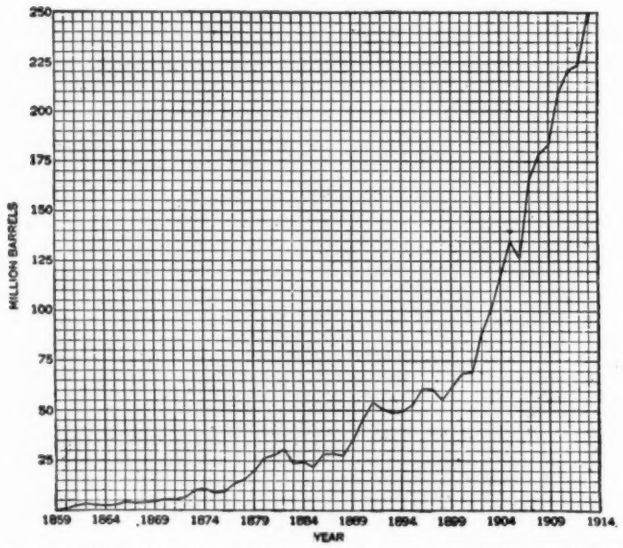


FIG. 1. PETROLEUM PRODUCTION IN THE UNITED STATES

substitutes for certain petroleum fractions, particularly gasoline. None of these suggestions, however, rivals shale oil in available quantities nor in general applicability.

A third group of what may be termed petroleum substitutes is found in a field foreign to liquid fuels. Materials in this class are powdered coal, coal-oil mixtures, byproduct gas, and even electricity. These sources of heat, light and power would, of course, readily lend themselves to many of the purposes for which petroleum is now applied. In any general discussion, therefore, the possibilities in these directions must be considered carefully.

Present Applications of Petroleum

An extended discussion might be developed of all these varieties of supplementary or substitute materials. For the present article, however, they cannot be considered in detail. As pointed out previously, all materials and methods taken together are not enough to bring the present supply up to the total demand. For this reason it is more profitable for the present to turn to the third national question as to how the available supplies can be used to best effect during such period of inadequacy.

It is not practicable to give any exact statement of the present uses of petroleum, but an excellent idea of the principal applications is obtained from the Bureau of Mines' figures of refinery output in this country during 1919. The important points in this summary are as follows:

Product	Output, Millions of Gallons
Gasoline	3,958
Kerosene	2,342
Gas and fuel oil	7,627
Lubricants	847
Miscellaneous	1,279
	16,053

The gasoline, of course, goes principally into automotive and other internal-engine uses. The kerosene is to some extent used for internal-combustion engines, but primarily is an illuminant. Lubricating oils, of course, have obvious application. The gas and fuel oils go into naval and marine-engine and power-plant applications, to the water-gas and oil-gas manufacturer, for a wide variety of industrial heating and steam raising, and to some extent to industrial chemical applications. The miscellaneous output is made up of specialized products which are applied in many fields, partly as fuels but also largely for other uses, such as inks, medicinal products, paints, road oils, etc.

A still more significant method of classifying the present distribution of petroleum was used by the United States Geological Survey in its study of the fuel- and gas-oil requirements. This bureau summarizes some of the major demands in this field from official sources as follows:

	Barrels
Shipping board—for merchant marine, 1920	40,000,000
Shipping board—for merchant marine, 1921	60,000,000
Navy requirements, 1918-19	5,500,000
Navy requirements, 1920-21	8,000,000
Railroads, 1918	36,700,000
Gas manufacture	25,000,000
Other public utilities	11,000,000
Crude oil used on leases	5,700,000
Total accounted for, 1920 (approximate)	150,000,000

This tabulation is by no means a complete representation of fuel-oil demands, but it indicates the order of magnitude of the requirements of some of the principal users that have been conspicuously in the market during recent months. They, indeed, represent over 60 per cent of the United States fuel-oil requirements at present, it appears. The notable increase in the requirement of the merchant marine and Navy is a point that should be particularly considered in this connection.

Not all users of petroleum products are in competition with each other for their supply, because certain of the products are available only for a limited variety of uses. It is undoubtedly worth while, therefore, to consider the relative importance of the various demands for these materials. As a result we can gain at least some measure of the economic justification of these applications and establish what might be termed an economic priority list for petroleum.

A Petroleum Priority List

During recent years we have had a variety of bases for determining priorities. During the war period priority commonly was granted to a specific individual or firm in order that a particular job on hand might be accomplished expeditiously. Then, too, we had priority classes for fuel in which the character of the institution served or the nature of the work to be done by the fuel user determined his position in the list, as, for example, the relatively high placing of public institutions, hospitals, etc., the intermediate ranking of public utilities, and the superior ranking of war indus-

tries over those termed "non-essential." Still more recently, in the case of coal transportation, another class of priority has been granted by the Interstate Commerce Commission; that is, according to geographical subdivision. This was done to provide that New England and the Northwest would not freeze or be threatened with idle industries during the coming winter season. However, none of these priority systems serves for the present purpose. What is needed rather is a scale by which we may judge the relative social service performed and thereby establish the economic justification for priority.

It is realized that any effort to this end cannot expect to command general concurrence with every detail; in fact, there will perhaps be as many priority lists established as there are investigators in this field. However, there are certain principles to which practically all will agree, and these justify careful consideration in the hope that at least we may establish some basis to guide the industrial thought for the immediate future.

In the following discussion of such priority it is intended to take rather a middle ground between what can be our everyday practice this year and what might be termed an ideal future practice toward which to work. As a result the suggestions of the following sections are a recommendation toward which it is believed we can immediately turn with the expectation of realizing the relationships suggested within a few years. Still further development beyond that period will also be needed. However, it is impossible for anyone to say now just how each of the several interests that must be regarded as competitive today will develop or to prejudge their proper rank for periods of the more distant future. This limited applicability over relatively few years should be carefully borne in mind in order to avoid a misunderstanding of the rather high position given to some uses of petroleum that cannot be recognized as worthy of such preference permanently.

The Influence of Price in Determining Priority

In the final analysis the laws of supply and demand, if unrestricted by artificial legislation, fix petroleum prices properly in reference to trade conditions. He who can still afford to pay the price thus fixed can expect to remain in the market as a successful purchaser; he who can least afford to pay the prices thus established will soonest be eliminated. This perhaps is the law of the jungle, but it is almost inevitable that it shall rule. A further consideration of some of the aspects of this principle, however, is worth while.

Liquid fuels are for most uses simply competitors of gas, coal and electricity as sources of heat, light and power. So long as liquid fuels afford to the purchaser an attraction superior to these other energy supplies, the purchaser will continue to use the liquid fuel if it be available. Price is, to be sure, only one of the elements in determination of the relative suitability of liquid and other fuel supplies. Convenience of use as compared with solid fuel, ease of storage as compared with gas, and other similar factors enter. However, in the last analysis the purchaser buys the one that gives him for the least expenditure of money and effort the desired operating result.

Under these circumstances as soon as the petroleum becomes decidedly more expensive per unit of service rendered than coal, let us say for heating, then the use of liquid fuel for this purpose will promptly cease. It is likely that price will thus establish a more or less sound basis for determining industrial priority especially if unaffected by governmental restriction. Indeed, one might say that such a priority list established by ability to pay the price will ultimately be identical with a list established solely on the basis of the economic justification for use of the liquid fuel. Nevertheless, it is worth while to consider these problems from a little broader point of view. To this end let us consider a dozen of the principal applications of petroleum.

Lubrication, Illumination and Special Demands

Probably nearly a unanimous opinion can be expected with respect to the first on the priority list; for a general agreement certainly can be looked for with the thought that lubrication is the most important and most

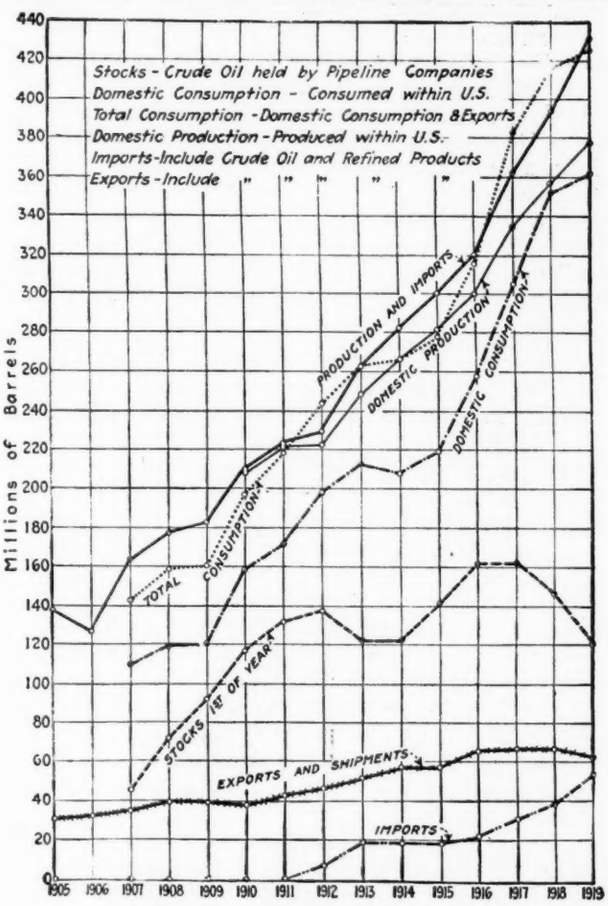


FIG. 2. PETROLEUM CONSUMPTION, IMPORTS AND EXPORTS

nearly irreplaceable application of all petroleum products. One is safe, therefore, in placing this requirement at the head of an economic priority list.

Next in order one must probably place either illumination or the special chemical requirements for miscellaneous petroleum fractions. Of these two uses the former draws upon rather a different group of oils from the latter. It, therefore, makes little difference which is placed second and which third in our list. Kerosene, as an illuminant for districts where city gas, electric current or acetylene is not available for lighting, certainly serves a fundamental social function that

is hard to care for otherwise. Moreover, this use of kerosene calls for only a portion of the illuminating oils which can be manufactured from the available petroleum resources that will be handled if demands in other lines are met. There seems some ground, therefore, for placing illumination as number two in the schedule.

Numerous chemical processes require the use of liquid fuels, but these do not draw very heavily upon our petroleum supplies. To the extent that neither gas nor solid fuel seems quite as well adapted to the processes in question, so far are we justified in giving distinct preference to this requirement.

Within the chemical industry there is also a highly specialized requirement of petroleum fractions which are used not for fuels, but rather for other purposes. Ink oils, medicinal oils, petrolatum, paint oils and similar petroleum products are conspicuous examples. These demands represent applications that certainly justify encouragement. And fortunately, this encouragement can be given without any particular burden upon other uses, as the quantities needed are very small indeed compared with other requirements.

Within the group of chemical requirements there is, also, a peculiar class that is rather the result of the existence of products not readily adaptable to other uses. To the extent that these relatively inferior products can be efficiently applied in chemical industry, we would give great encouragement to such use. All these so-called "chemical" uses are grouped together and placed as third in the economic priority schedule proposed.

Automotive Fuel Requirements

The requirement of petroleum fractions for automotive fuels is peculiar in that the fraction commonly needed is not largely in demand for any other use. Gasoline is, in fact, almost synonymous with automotive fuel. Practically all gasoline can be given to automotive requirements and this use placed as number four in a priority list without giving rise to any serious objection.

The only sense in which automotive requirements are in conflict with other demands for petroleum is that fuel-oil fractions are now being used to a considerable extent for the production of gasoline by cracking. In placing automotive requirements as number four, it is not intended to include with them this indirect production of gasoline; this rank of four is confined to the gasoline produced by the older methods of distillation.

It is well known that all the gasoline that can be made by present-day plant practice is quickly absorbed by the markets. The competition or priority with respect to gasoline, if such were undertaken, would therefore require a very different type of classification from that which we are now discussing. It would require, in fact, a discrimination between uses of greater and lesser economic justification; in other words, a contrast between essential, desirable and purely luxury applications. To enter a discussion of that question is, for the present purposes, wholly unnecessary.

Competitors for Gas and Fuel Oils

After recording the first four entries on a priority list, a more difficult problem is met, for at this stage one must decide as between those who require substantially the same fractions of petroleum. There are eight groups of gas-oil and fuel-oil uses that must be so judged and ranked. These applications are: Gas manufacture, gasoline manufacture, internal-combustion (Diesel) engine use, navy fuel, merchant-marine fuel, locomotive fuel, steam power-plant fuel, and fuel for heating plants.

In this group gas manufacture is set apart because it represents a distinct type of fuel-oil application. Other public-utility fuel users would also require special treatment were it not for the fact that their oil requirements fall within the scope of the remaining groups mentioned. For example, these other public-utility uses are in Diesel engine, power plant, or heating plant; and for present purposes these need not be distinguished from similar demands by other users.

Gas and Gasoline Manufacture

It is a general principle in our census of manufactures that a measure of industrial development is the value added by manufacture. For this purpose value of raw materials compared with value of products and the difference taken by the census as of economic significance. Proceeding upon the same theory here, we can place gas manufacture and gasoline manufacture somewhat ahead of other demands for fuel oil. In these applications the oil is not consumed, but rather is converted into a material available for application in a superior class.

If it were possible quickly to substitute coal-gas plants for existing oil-gas and carburetted water-gas installations, there would be no particular need to regard the city-gas manufacturer as entitled to serious consideration for high place in a priority list for fuel oils. However, such quick change of gas-making process is not possible. The machinery and materials needed for installation of coal-gas or coke-oven plants cannot be made available for a considerable period, nor can the funds required for so large a change in investment be secured by utility companies at present. Gas represents an essential of modern city life. For the present and a considerable number of years to come, therefore, preference must be given to gas manufacture over other fuel-oil requirements to such extent as will permit uninterrupted adequate gas supply.

This situation may continue longer than at first seems likely, for natural-gas supplies are now continuously decreasing in quantity, and manufactured gas must inevitably ultimately replace them. Much new construction of coal-gas and coke-oven plants will doubtless, therefore, be directed to extension of gas-making facilities in such districts of the country. Municipal growth and extension of gas supply into suburban territory also tend to limit gas-works construction to that which can be regarded as extension of present plants. Thus, for many years to come an important fuel-oil demand for water-gas making will be met.

Gasoline production from fuel-oil fractions, when it can be efficiently practiced, raises the petroleum production from a lesser to a greater usefulness. To the extent that equipment is available for this conversion to gasoline, preference will doubtless be given for such use by the petroleum refiners. This will be not only a matter of good business judgment on their part, but also, for the reason cited, an economically justifiable procedure. On the other hand, Diesel-engine use is so much more efficient than most gasoline-engine use that there is no ground for encouraging conversion of fuel-

oil to gasoline for work which the Diesel engine can do. Therefore, as Diesel-engine demand develops, this new factor will enter to offset the present tendency toward cracking to make "gas."

Oil for Fuel and Power

Having disposed of gas-making and gasoline manufacture, there remain only power and fuel uses for consideration. Because of the greater efficiency of petroleum use in internal-combustion engines as contrasted with boilers of any type, we certainly must give preference to this use. As a matter of fact, this, for the immediate present, is not of large commercial significance because the internal-combustion engine (limiting ourselves here to the non-automotive type) does not demand any large percentage of our fuel-oil supplies. Nevertheless, with increasing costs of liquid fuels we may look forward to great increases in this more efficient method of fuel-oil utilization; and as these uses develop, we probably shall continue to place them at this point in any priority schedule that may be evolved.

The remaining users of fuel oil burn it under a boiler or for direct heating purposes. Of these users the naval requirement unquestionably comes first. Following this, most would doubtless agree that the merchant-marine demand should be met before other use can be justified. That this merchant-marine demand is going to increase continuously in the next few years cannot be questioned. Not only are the estimates from the United States Shipping Board good evidence of this, but also there is extensive development of oil-fired shipping by the British. In fact, the "Olympic" and "Aquitania," two great Cunarders, only recently made their maiden voyages as oil-burning vessels with very gratifying results.

After these marine uses we can probably give the locomotive boiler next position. The large advantage of liquid fuel for such mobile power plants is well recognized. To the extent, therefore, that the locomotive cannot be electrified, we can justify oil burning in preference to the use of oil for stationary power or heating-boiler use. This preference is also supported by the critical state of the transportation demands of the country at the present.

It is to be anticipated that this preference for locomotive use will not continue long except in certain limited portions of the country where liquid fuels are much more readily available than solid fuels. Oil for locomotives is rapidly becoming prohibitive in cost or wholly unavailable.

As a matter of fact, by the time we reach this stage it makes little difference to whom we give priority; for if the higher classes of use are satisfied, there is no oil left to distribute. Nevertheless, one may as well continue to theorize through to the end, and discriminate between the steam-power plant and the heating plant. It appears that the former should be given preference over the latter, for a greater increase in efficiency is doubtless generally obtained in power production through oil firing as compared with solid-fuel firing, than can be found in contrasting liquid-fuel and solid-fuel use for heating purposes. Thus we would place steam-power-plant use ahead of heating-plant application, the latter being the last of the twelve items in the schedule.

As a result of the foregoing discussion one obtains a priority list for liquid fuels as follows:

Character of Use	Kind of Oil Applied
1. Lubrication	Lubricants (fuel oil)
2. Illumination	Kerosene
3. Chemical processes	Miscellaneous
4. Automotive engines	Gasoline
5. Gas manufacture	Fuel oil
6. Gasoline manufacture	Fuel oil
7. Internal-combustion engines	Fuel oil
8. Navy	Fuel oil
9. Merchant marine	Fuel oil
10. Locomotive firing	Fuel oil
11. Steam-power plants	Fuel oil
12. Heating	Fuel oil

This schedule will doubtless wholly meet the ideas of few, but it represents the application of a relatively new principle in national-resource thought, and as such it should be generally considered. In any event, whether one agrees with it or not, it represents a starting point for the consideration of a still more important engineering problem, namely: What attention must be given to petroleum substitutes in order that all these industrial needs for liquid fuels may most effectively be met? This latter question requires separate discussion.

Diesel Central-Station Costs

In 1916 the Texas Power and Light Co. installed three 500-hp. McIntosh & Seymour Diesel engines in the Paris, Texas, station. These Diesels are direct-connected to alternators and are delivering power into a 100-kv. transmission line in parallel with a steam-turbine plant at Waco, over one hundred miles away. It is of interest to engineers to learn that these Diesels deliver a kilowatt-hour at a total cost well under the cost at the Waco steam-turbine plant.

At the time the plant was installed, very exhaustive tests were made on the units. The maximum efficiency secured during these tests was 0.603 lb. of fuel per kilowatt-hour. In the report appearing here, the average consumption is 0.657, showing less than a 10 per cent increase over the full-load test values.

It is more or less a mooted question as to the continued efficiency of a Diesel engine. Many engineers are under the impression that the low fuel consumption

PRODUCTION COSTS, PARIS, TEXAS, DIESEL STATION

	1919	Sept. 1—Dec. 31, 1916
Engine hours	24,047	
Gross kw.-hr.	7,580,130	
Net kw.-hr.	7,507,940	1,565,000
Station factor	93	51
Fuel oil, lb.	4,988,120	149,072
Fuel oil per kw.-hr., lb.	0.657	0.672
B.t.u. per kw.-hr.	12,700	13,100
Labor per kw.-hr., mills	1.577	1.44
Fuel per kw.-hr., mills	3.130	3.07
Water per kw.-hr., mills	0.0503	0.09
Lubrication per kw.-hr., mills	0.1748	0.04
Miscellaneous supplies per kw.-hr., mills	0.235	0.10
Building repairs per kw.-hr., mills	0.0945	0.05
Engine repairs per kw.-hr., mills	0.51	0.04
Auxiliary repairs per kw.-hr., mills	0.0103	0.15
Electrical equipment repairs per kw.-hr., mills	0.0873	
Miscellaneous station repairs per kw.-hr., mills	0.0167	
Total production cost, mills	5.99	4.98
Overhead, per kw.-hr., mills	4.85	4.85
Total cost, per kw.-hr., mills	10.84	9.83

is secured for only a few months at best. To the contrary, if the oil engine is maintained in first-class condition, the fuel consumption remains practically constant over a long period of operation. Probably no form of prime mover experiences a smaller drop in efficiency

from wear and tear than does the Diesel. The increased costs in old engines is due almost entirely to higher maintenance charges.

In the table shown, the production costs are given for the four months from Sept. 1 to Dec. 31, 1916, and for the entire year of 1919. It will be noticed that the fuel consumption per kilowatt-hour has decreased. This is due to the increased station factor. The increase in the labor charge follows the rise in wages experienced during 1919. All the several maintenance items show an increase. With the entire equipment requiring more repairs, as is but natural, and with increasing costs, these items are very low. The record of 24,047 engine hours in 1919 shows that the three engines were in operation for over 90 per cent of the time, which compares favorably with the performance of a steam plant of like size.

If the overhead charges are assumed to remain at the same figures as were used in estimating the total power costs in 1919—namely, 4.85 mills—the present total cost per kilowatt-hour is 10.84 mills, or an increase of one mill per kilowatt-hour over the 1916 costs.

The operating procedure has had an important influence over the fuel and repair costs. The engines are usually run slightly below the normal horsepower rating. On Sunday one unit is shut down and necessary adjustments are made. At this time, the valves from one cylinder are removed, an extra set replacing them; the valves are cleaned during the week. Each set of valves then, is removed and cleaned every three months, while bearing adjustments, etc., are made every three weeks. A unit is out of service from two to ten hours at this adjustment period.

The station force is much smaller than for a steam plant of like capacity. There is a chief engineer in charge of the plant, and on each shift there are one watch engineer, one helper and a switchboard operator, or ten in all.

Jones Spur-Gear Speed Reducers

The Jones spur-gear reducer, manufactured by the W. A. Jones Foundry and Machine Co., of Chicago, has been made in its present form for the last three years. Its possible uses are numerous—in fact, with any machine that it is desirable to operate at a considerable reduction in speed from that of the driving motor.

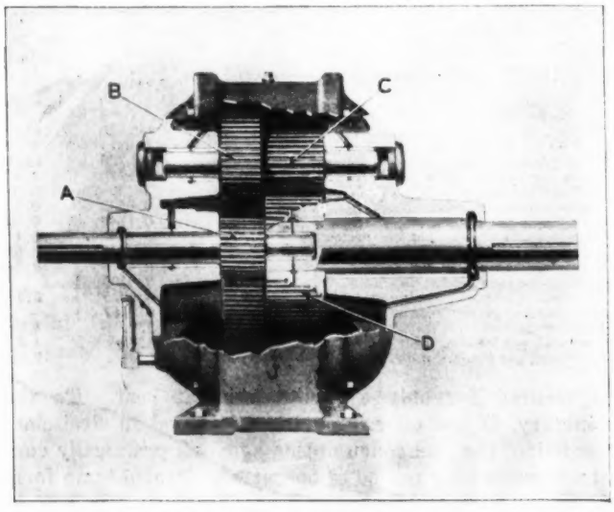


FIG. 1. SINGLE-TYPE JONES REDUCER FOR REDUCTIONS UP TO 15 TO 1

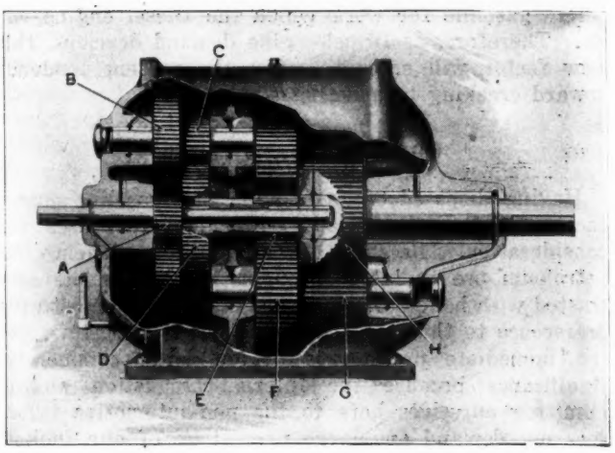


FIG. 2. DOUBLE-TYPE REDUCER USED FOR RATIOS OF FROM 15 TO 1 UP TO 200 TO 1

The reducer is an inclosed spur-gear drive with the high- and slow-speed shafts concentric and having the same direction of rotation. Connection to the machine on either side is made by means of flexible couplings.

All reductions are accomplished by means of plain spur gears, the tooth form employed being the involute stub with a 20-deg. pressure angle.

Fig. 1 is a sectional view of the single-type reducer, which is generally used for reductions up to 15 to 1. The double-type reducer shown in Fig. 2 is used for ratios of from 15 to 1 up to 200 to 1 or over if desired; its construction details do not differ materially from the single-type, except that a total of four reductions is accomplished instead of two, the housing being increased in width to accommodate the necessary gears. Reference to the illustrations will show that the pinion *A* meshes with and drives the three gears *B*, which are mounted integral with the three pinions *C*, these in turn meshing with and driving the slow-speed gear *D*. The gears *B* and pinions *C* are equally spaced around the high- and slow-speed pinion and gear at angles of 120 deg., thus relieving both the high- and slow-speed shafts and bearings of transverse loads due to tooth thrust. The pinion *A* is supported in correct alignment at one end by the bronze-bushed bearing in the reducer housing and on the other end by the slow-speed shaft extension, which carries a bushed bearing as shown in the illustration.

In the double-type reducer, Fig. 2, the gear *D* which corresponds to the slow-speed gear in the single-type model, is keyed to a sleeve that is integral with the pinion E. This sleeve is bronze-bushed and rotates on and in the same direction as the high-speed shaft. The extreme end of this high-speed shaft journals in the bronze-bushed bearing located in the end of the slow-speed shaft, the same as in the single-type reducer. The intermediate pinion *E* meshes with and drives the three gears *F*, which are mounted integral with the three pinions *G*, these in turn meshing with and driving the slow-speed gear and shaft *H*. The back gears and pinions are equally spaced at 120 deg. as in the single-type reducer, but the set on the slow-speed end are located intermediate, or 60 deg. from those on the high-speed end.

Standard reducers suitable for all motor speeds are made, ranging from 1 hp. up to 200 hp. and almost unlimited reduction can be obtained.

EDITORIALS

Application of Induction Motors

THE problem in the application of motors to the driving of any piece of machinery is to select one that will have sufficient torque to start and accelerate the load within the period that may be imposed by the particular condition and do this with a reasonable value of current from the line. It must also have sufficient capacity to drive this load for the required period, as well as a reasonable overload, without overheating. Where necessary, the motor must lend itself to speed adjustment to meet the requirements of the drive. With the exception of applications requiring wide ranges of speed adjustment, induction motors can successfully meet these requirements. However, the foregoing covers considerably more than might at first thought indicate, and in general the importance of correct motor application is not fully appreciated.

Improper applications of motors in practically all cases cause the maintenance costs to be higher, not infrequently increase the power consumption of the motor, and in the case of induction motors may create conditions that will increase the losses in, and reduce the useful capacity of, all generating, transforming and transmission equipment. To this must also be added the losses due to reduced production from the machine the motor is driving and not infrequently the loss due to an inferior product. Once a motor and controller are incorrectly applied to a drive, unless the defect is too serious it is allowed to continue and the losses due to misapplication pile up each year without corrective measures being taken. A frequent occurrence in the application of motors is selecting one of either too great or too small a capacity for the load. Of the two it is better to have the motor too large. If the motor is overloaded, burnouts will be frequent and a loss of production from the driven machine will result. With an underloaded direct-current motor about the only objection that can be raised is the increased first cost and slightly decreased efficiency. However, with an induction motor, in addition to the foregoing the power factor will be low, with its many deleterious effects on the whole power system. Besides, if power is purchased a penalty in the form of an increased rate may be imposed for poor power factor.

To select a motor of the proper horsepower rating for a given load frequently requires a very careful study of the characteristics of the load; especially is this true if the load is intermittent. If a motor is selected with a continuous horsepower rating equal to the maximum load, it may be operating for considerable periods at only partial loads. In such applications it will frequently be found that a motor rated on a one- or two-hour basis will do the work and give better satisfaction all around, at a considerable saving in first cost and in power consumption after installation. Or by selecting a motor of the proper characteristics and using a flywheel, a considerable saving can be made in the size of the machine as well as improving its service.

The proper application of motors is no longer a matter of guesswork, as shown by Frazer Jeffrey in three articles on the "Application of Induction Motors," the first of which appears in this issue. In these articles Mr. Jeffrey has outlined sixteen general features to be considered in the application of motors. Although these do not cover all features of application, since there are points that will naturally arise due to peculiar local conditions, nevertheless if a motor is selected for a given condition to meet the sixteen features outlined, it will in a large percentage of cases be highly satisfactory.

The British Coal Strike

THE coal miners of the British Isles have at last taken the grave step they have for a long time been threatening. On the surface they are striking for a few more shillings a day. Their real purpose is the nationalization of the coal mines. What railroad brotherhoods in the United States would do under the Plum Plan, the British coal miners would do for their industry.

As this is written, they are storming Downing Street in an effort to reach the Prime Minister's residence. They give the police an ugly fight. And this is, perhaps, indicative of their temper in this matter. Of course these miners will leave nothing undone to get the other great unions in the fundamental industries to join them and thus more completely disjoint the life of the British Isles. It is impossible to forecast accurately whether they will or will not get such co-operation. Our guess is that they will not. It is not so long ago that Englishmen turned to and operated the railroads when the workers went out for a cause not supported by public opinion; it has recently been demonstrated again and again that a strike not supported by public opinion must fail. The British coal strike seems, at this distance, to be in this class.

But the strike may continue for some time, and it is this that immediately concerns us in the United States. A strike of such magnitude in such a basic product as coal, and occurring in a country which exports so much of it, brings precipitous panic to the coal markets of the world. The first move of the British government was to stop the export of fuel. Immediately there will follow a great increase in exported coal from the United States. This will in all likelihood force up prices to consumers at home. If the strike continues for long, we in America will pay our share of the cost.

It is not a bit too soon for the United States Government to act to prevent a flood of coal for export. Exporters know that if they can deliver the coal they can get their price, whatever it may be. The profiteering side of the situation is not the worst side; the abominable part of it all is that we at home, next door to the coal mines, the mines of the United States, must bid against the panic-striken buyers of Europe, who will pay any price for our coal.

The power-plant men of the country, who consume about forty-two per cent of the coal mined will watch with deep concern for such action by the Government as the conditions may warrant to insure the full measure of protection to consumers here at home.

Safety-Valve Openings

THE Boiler Code of the American Society of Mechanical Engineers provides that a boiler shall have sufficient safety-valve capacity to discharge all the steam that it can generate without allowing the pressure to rise more than six per cent.

While numerous methods of determining the maximum generating capacity of a boiler are suggested, it is stipulated that the total relieving capacity for all other types of power boilers than the water-tube shall not be less than five pounds of steam per hour, per square foot of heating surface for pressures above one hundred pounds.

When the steam to be discharged exceeds 2,000 pounds per hour, two or more safety valves must be used. Each safety valve must be stamped with the maker's name or trade mark, the pressure at which it is set to blow, the number of pounds of steam that it will discharge per hour at that pressure, and "A.S.M.E. Std."

A boiler manufacturer took an order for some 72-in. by 18-ft. horizontal return-tubular boilers for one hundred and fifty pounds pressure. These are listed by the maker at one-hundred-and-fifty horsepower, and said to contain 1,436 square feet of heating surface, which, at five pounds per foot, would require a relieving capacity of the safety valves of 7,180 pounds of steam per hour.

The order called for "one four-inch (or larger to comply with the ratio for grate surface) reinforcement riveted on top of shell for safety valves."

The "ratio for grate surface" refers to a provision of the rules of the Industrial Commission of Ohio, into which state the boilers were going, in which safety-valve area is made dependent upon the grate surface.

The boiler maker, in accepting the order, explained that since the capacity exceeded two thousand pounds per hour, he would be obliged to provide openings for two smaller valves instead of for the single four-inch valve called for.

In this he was right, in a way, although if he had built the boilers with the four-inch nozzles or reinforcements, as the customer wanted them, the customer could have complied with the Code by using two valves on a yoke or Y mounted upon that opening. The maker, however, instead of providing nozzles or reinforcements for some such combination as one three-inch and one two-and-a-half-inch valve, which would hardly provide the required capacity with a pop safety valve of the usual design at a medium lift, simply tapped a hole into the shell for a one-and-a-half-inch valve and put on a reinforcement pad for a two-inch.

This was pretty small for a seventy-two-inch boiler, but there are valves upon the market which, by virtue of their high lift, are guaranteed to relieve over 8,600 pounds per hour in these dimensions and at this pressure. Equipped with such valves, the boiler would comply with the Code so far as safety-valve relieving capacity is concerned, and having fixed it so that it could be equipped with such valves, the builder felt that he had built a Code boiler.

But the customer, knowing nothing of high lifts and relieving capacities, went out and bought ordinary pop safety valves such as were common in his market, to fit the holes that the builder had made in his boiler, just as ninety people out of one hundred would have done.

And then comes the boiler inspector, who refuses to pass the boiler because it has not sufficiently large safety valves—which, of course, it has not.

Here is a costly and disagreeable situation. Who is at fault, the Boiler Code, the boiler builder, the customer or the inspector, and what is to be done about it?

The Petroleum Situation

EVERY *Power* subscriber should turn to page 665 and read R. S. McBride's discussion on the condition of the petroleum supply. The public at large has always discounted prophecies of exhaustion of natural resources, and its attitude on the liquid-fuel situation will probably be likewise. It then becomes the duty of the engineering world to recognize present-day conditions and attempt some solution of this question.

Usually, with diminishing resources the law of supply and demand tends to enforce the practice of economy, thereby lessening the danger of total extinction of the particular commodity. Unfortunately, conditions in the petroleum industry preclude the successful operation of this law. The greatest market for petroleum is the automobile industry, where the actual consumption of gasoline per individual purchaser is comparatively low. A rise in price would then have but small influence toward a decrease in demand If the demand for gasoline could be reduced, the "cracking" .of heavy oils and the mixing of kerosene and casing-head gasoline would decrease. This would release more heavy oils to those users who are practicing economy.

Some procedure that will lessen the petroleum demand must be instituted. A priority list is suggested by Mr. McBride as a solution. As a further step, undoubtedly a method of distribution where supplies would be available to those who extract the greatest possible percentage of the heat in the fuel would be eminently fair.

A local chapter of one of the engineering societies has inaugurated a move to ascertain and classify the personal qualifications of its members with a view to more intelligent committee assignments. Inquiries are being addressed to the members, asking them to name those among their associates who can make a good address of welcome, those who have musical ability, are able to tell a good story, are interested in athletics, etc. The idea is an excellent one. Every society contains many men capable of doing good work along these lines, but often they are either overlooked or put on work for which they are poorly fitted. The more active members a society has the healthier it will be and the more rapid its growth.

On several occasions during the present political campaign the American Association of Engineers has seized the opportunity of questioning candidates on matters directly concerning the engineering fraternity; not with a view of committing the association to any one party, but in order that its members may more intelligently judge for themselves. This is admittedly a new departure for an engineering association and seems to have startled some of the conservative members of the profession, but if the effort accomplishes nothing more than to help put engineers on the map, it will not have been in vain.

CORRESPONDENCE

Correct Height of Return-Tubular Boiler

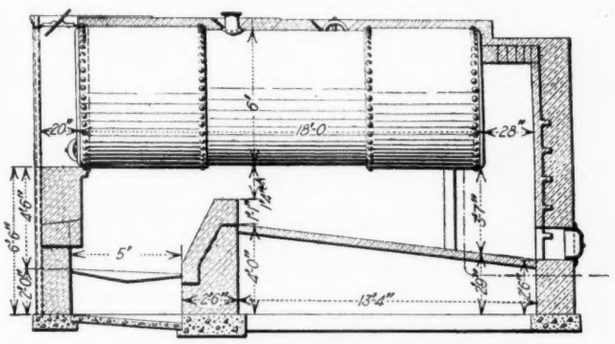
Mr. Misostow, in his article on page 1034 of the June 29 issue of *Power*, I believe, has defined the proper relation of setting a horizontal return-tubular boiler and hand-fired grate in his brief statement, "We must set the boiler as close to the source of heat, which is the fire, as possible and still have a furnace which will allow perfect commercial combustion in the presence of the boiler at the predetermined distance."

This is a proper definition of the correct setting of any boiler and it must be appreciated, as stated in the article, with particular reference to the horizontal return-tubular boiler, that it is of advantage to distill the volatile of the coal at as uniform a rate as practical, rather than cause the distillation to approach the flash or explosion phenomenon by maintaining a furnace temperature that is too high. When we consider what I believe to be the basic principles of a good and complete combustion, the advantages of slow distillation are evident. For proper combustion there must be an intimate mixture of air and combustible gases with sufficient air to supply combustion, and this mixture must be maintained at a temperature high enough to cause the ignition of the combustible gases while they are mixing or being mixed with the air.

The particular advantage that we see in the removal of the arches and brickwork, referred to in Mr. Misostow's article, is in allowing the absorption of heat by the boiler through radiation from the fire and flame and the great reduction in furnace-temperature resulting, with correspondingly slower distillation of the volatiles and lower flue-gas temperature, and also in a majority of cases the formation of less clinker.

I do not believe that the reduction in the height of the setting, referred to by Mr. Misostow, would have any appreciable effect on the heat transfer by radiation. My analysis of the improvements resulting from the furnace changes described in the article would be to attribute them entirely to the removal of the brickwork under the boiler shell, and I would not credit any improvement to lowering the boiler. The removal of this brickwork allows the absorption of more heat by radiation and also increases the amount of combustion space. The installation, in the final setting, of deflecting pier and wing walls in the combustion chamber acknowledges the necessity of thoroughly mixing the combustion gases with the air and at the same time keeping them at as high a temperature as is practical, this being accomplished through the heat in the brickwork of the wing walls and deflecting pier.

I would take exception to the statement that the temperature in a hand-fired furnace seldom exceeds 1,800 deg. F. However, at such a temperature I am not able to check the figure of 52 cu.ft. of gas to the pound of coal. Rough calculations of the volume of gas at 1,800 deg. F. per pound of coal, with a combustion producing 20 lb. of gas per pound of coal, give approximately 1,050 cu.ft. of gas for every pound of coal burned. Using the velocity of 20 ft. per second for gases over the bridge wall, as given by Mr. Misostow, and the correct volume of these gases, I calculate an area of 43.8 sq.ft., as compared to 2.17 sq.ft. given in the article. Following the method used in the article



BOILER SET FOUR FEET ABOVE GRATES

to determine the setting height, there results the height of 44 ft. 9½ in. from grate to boiler shell. Evidently, therefore, the stated velocity is in great error.

Just what velocity should be used is a question, but it appears that since experience has proved wing walls and deflecting piers in the combustion chamber to be unsatisfactory from the maintenance standpoint, it is well to increase the velocity of gas passing over the bridge wall to such a point as to pass through the critical velocity—that velocity where the stream-line flow ceases and eddying begins—and proportion the combustion chamber beyond the bridge wall, so as to permit a slowing down of the gases. This will produce the mixing effects desired under temperature conditions supporting combustion.

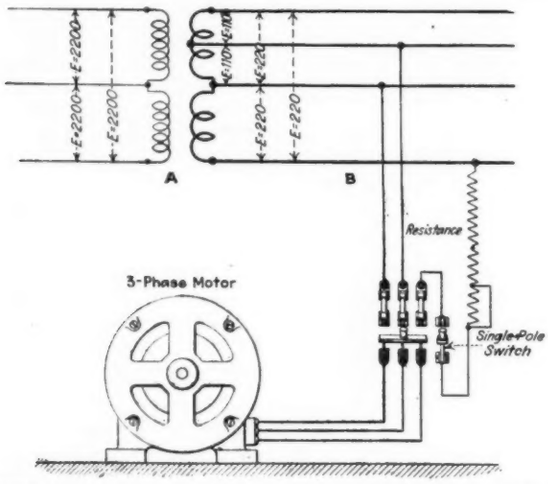
This idea is expressed in the setting shown, wherein the dimension 1 ft. 4 in. from top of the bridge wall to the boiler shell is considered a minimum and is subject to variation in individual installations. Analyses of many existing installations show that the old practice of low setting is not so advantageous as a distance of 4 to 4½ ft. from the grates to the boiler shell.

Cleveland, Ohio. M. K. BRYAN.

Operating Three-Phase Motor on Single-Phase Circuit

One of our customers had a three-phase 110-volt induction motor, that he desired to use on premises where the only current available was a four-wire service of 110-220 volt single-phase and three-phase 220-volts, as at *A* in the figure.

The motor was examined and found to be single-series star-connected, which made it impossible to adjust



CONNECTIONS FOR STARTING A THREE-PHASE MOTOR AS A SINGLE-PHASE MACHINE

the connections for running it on 220 volts without rewinding. It was decided to try running it as a single-phase machine if the load to be carried was not too heavy. As is well known, a three-phase induction motor will operate satisfactorily, once started, if the load to be carried as a single-phase machine does not exceed 40 per cent of the three-phase output. The motor was installed, started by hand and tried out on the load to be carried, and found to be satisfactory.

No phase-splitting devices being immediately available, it was decided to use the other leg of the three-phase 220-volt supply for starting, simply inserting a resistance in the circuit with the third wire to cut down the impressed voltage. The motor was one horsepower rating, therefore the three-phase starting current was assumed to be about nine amperes. After starting, the current would drop to about three amperes as the speed came up to normal. To use a resistance just the right size for the starting current would endanger the motor from overvoltage when the current decreased, as the drop in the resistance would be reduced as the current decreased. Resistance enough to maintain balanced voltage at three amperes would necessarily cut down the starting torque, but this was considered preferable to endangering the motor. This gave the resistance equal volts divided by amperes, or $110 \div 3 = 37$ ohms. Heating elements from two 550-watt 110-volt flatirons were mounted on an asbestos base and connected in series. This gave 44 ohms, and after shunting one-half of one element, 33 ohms was obtained, which was close enough. Connections as used are shown at *B*. Two of the motor leads are connected across the 110-volt supply and the other, in series with the single-pole switch and the resistance, to the other phase of the supply.

The motor is started by closing both switches, and when full speed is reached the single-pole switch is opened, leaving the machine running as a single-phase machine. The device is giving perfect satisfaction, cost less than a standard phase-splitter, and saved time by not causing delay while a standard starter was obtained.

Eddyville, Iowa. HENRY H. BRUNNER.

Behavior of a Semi-Diesel Oil Engine

I am operating two 100-hp. vertical semi-Diesels of the dry type direct-connected to alternators. The load conditions are bad; for fourteen hours there isn't enough load to show on the meters, and then it jumps to 16 amperes per phase.

One night my operator called me on account of the engine stopping. I tried to start it, but found one of the pistons was seized. When I finally got the engine up to speed, it would start to slow down and finally stop. I had to repeat the starting two or three times. When it finally did start, everything was all right and no more trouble occurred for some time. I carry the cooling water at 155 deg. F. on light load and at 120 deg. on full load. What causes this sticking of the piston?

The engine has a pound which I cannot locate. When I start it up there is no noise, but after about fifteen minutes the pounding begins and keeps up. I have all the bearings very snug. Where does the pound come from? Four cylinders have cracked at the exhaust end air port bridges. What causes this?

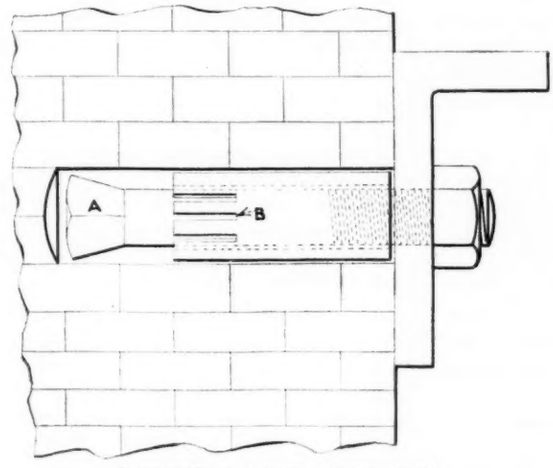
Bracketsville, Tex. JOHN M. TONEY.

[Possibly some of *Power's* readers who have operated similar engines can answer Mr. Toney's questions.—Editor.]

Easily Made Expansion Bolt

When expansion bolts are required, it pays to buy the factory-made article. However, very often a bolt is wanted in a hurry, and the plant may be situated at considerable distance from any source of supply.

Different emergency bolts have been described, more or less difficult to make. The one shown is easy to



EMERGENCY EXPANSION BOLT

make by taking an ordinary bolt and filing the head tapered as shown at *A*. Then take a short piece of lead pipe and with an ordinary handsaw cut several slots in one end as shown at *B*. Place the pipe over the bolt and as the nut is tightened on the bolt, the tapered head is drawn into the lead pipe, thus expanding it.

Portsmouth, Ont. JAMES E. NOBLE.

Faulty Valve Adjustment Caused Loss

The diagrams shown in Fig. 1 were taken from a 14½ x 30-in. slide-valve engine. Diagram *A* shows the condition of the valve adjustments as found. Diagram *B* shows the condition after advancing the eccentric 22 deg. The average steam consumption per horsepower-hour calculated from diagram *A* is 75.3 lb.; that from diagram *B* is 40.7 lb., a decrease of 34.6 lb. of steam per horsepower hour. For one year this would mean a

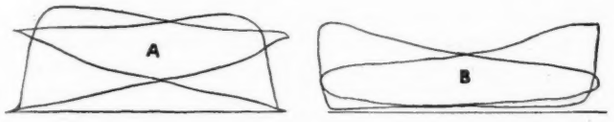


FIG. 1. BEFORE AND AFTER MOVING ECCENTRIC

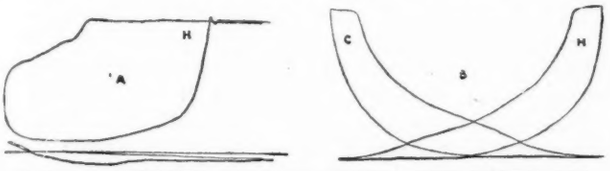


FIG. 2. ANOTHER CASE OF MOVING THE ECCENTRIC

saving of about 225 tons of coal, which at $14 per ton, the present price, would amount to $3,150.

The diagrams shown in Fig. 2 were taken from a 14 x 16-in. center-crank engine fitted with an automatic flywheel governor. The engine had for some time been giving trouble and was gradually getting worse. Diagram *A* shows the condition of the valve adjustment as I found it upon first indicating. The crank end showed a negative m.e.p. of 2 lb., caused by a slide-valve not opening during any period of the stroke. The head end was doing all the work, admission occurring when the crank end had completed 63 per cent of its stroke. The trouble was caused by the valve being screwed too far into the valve slides.

The steam consumption per horsepower-hour calculated from diagram *A* is 38.64 lb., and that calculated from diagram *B* is 20.09 lb., a decrease of 18.5 lb. per horsepower-hour, which made a saving of 123 tons of coal per year, which at $14 per ton would mean a saving of $1,722 per year. C. J. HALLORAN.

Avoca, Pa.

Boiler Drum Pitted

I recently made an examination of a water-tube boiler consisting of six drums, three below and three above. The feed water enters the rear lower drum through the side, and I found that this drum was pitted and corroded to a depth of from ⅛ to ¼ in. In the other drums there was not even a sign of pitting.

My theory is that, as the feed water entered the rear drum and as it was not passed through a feed-water heater, there was more chemical action taking place in the rear lower drum than in the others. If I am not right, I should be glad to have someone give me his opinion.

I also found that the short circulation tubes extending from one drum to another were only about halfway through the sheet. I considered that these tubes should have been properly flared or belled, which would have prevented this condition.

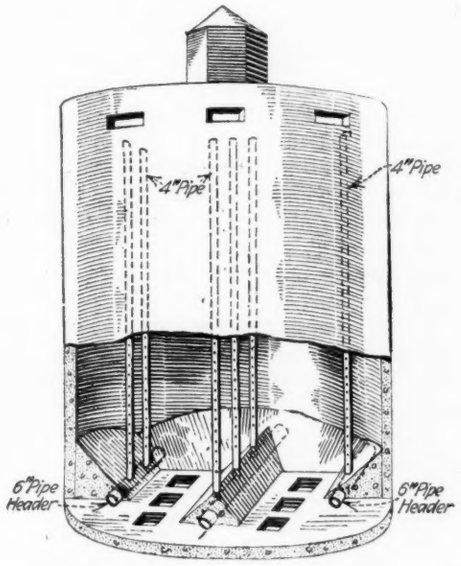
I had quite a lengthy discussion regarding the pressure in the different drums, with an inspector who had had over twenty years' experience. We could not agree, and we would like to have the opinions of *Power* readers. In the boiler mentioned this inspector claimed that the rear lower drum was not subjected to the same pressure as the others, and I contended that inasmuch as the pressure parts are all one unit, there is just as much pressure on the rear drum as on any of the others. CHARLES W. CARTER, JR.

Olean, N. Y.

Spontaneous Combustion of Coal in Storage

In the Sept. 14 issue, page 428, there is an article headed, "Spontaneous Combustion of Coal in Silo Bunkers." Coal is entirely too scarce to have such losses. One of my neighbors, several years ago, had trouble with spontaneous combustion of coal stocked in the open in a pile about fifteen feet in depth. It was necessary to remove it at great expense, as the fire could not be put out, although vast amounts of water were directed on it by the local fire department.

He avoided the trouble the following year by laying square wooden troughs on the ground with frequent hollow wooden columns connected vertically. These



VENTILATING PIPES FOR SILO COAL BUNKER

column had holes chipped in the corners every few feet. In this way free circulation of air was had through the coal and this prevented spontaneous combustion.

If the silo bunker under discussion were equipped with 6-in. iron pipe headers across the bottom and protruding through the sides to the atmosphere with a number of 4 in. vertical pipes, 8 ft. center to center connections with the header, with sufficiently large holes cut in them at frequent intervals and wire-shielded to prevent filling and obstructing a free circulation of air spontaneous combustion should be prevented. There should be a constant draft from the outside atmosphere through the piping R. L. BEARE

Jackson, Tenn.

Pounding in Semi-Diesel Oil Engines

In the Sept. 28 issue of *Power* A. S. Gabler describes the action of his 25-hp. oil engine. I had the same trouble with a 100-hp. and a 75-hp. semi-Diesel oil engine, both in a light plant. I am unable to answer all his questions, but can tell him how I got around the difficulty.

The builders of the engine advocate a temperature of 120 to 160 deg. for the cooling water. The temperature inside the cylinder is much higher. On a heavy load the heat produced by the combustion of the fuel is not carried away fast enough. We lowered the temperature to 100 to 110 deg. during peak load and used a medium-heavy grade of Diesel lubricating oil. This ended the trouble. A. W. GRATKE.

Strawberry Point, Iowa.

Mr. Gabler's engine trouble is largely due to overload. However, it is probable that the exhaust ports and possible that the air ports in the cylinder have filled up with carbon, due to excessive amounts of lubricating oil used in the cylinder.

It is not likely that the fuel pump is causing trouble, unless from the governor. If the governor "slams," or pounds against its stop, the pump will take a full stroke several times and then cut out for a few revolutions of the flywheel, causing the engine to run very irregularly. This can be remedied by tightening up on the governor friction, which makes the governor less sensitive.

The air intake valve into the crankcase may be clogged, especially if the air is piped in from outside the building.

As a last resort, and not at all to be recommended, a hole can be tapped into the air passage, between the crankcase and the cylinder, a check valve and small pipe line run from the water supply to this tapped opening and a small amount of water fed into the cylinder. This water, mixing with the scavenging air, will prevent preignition on heavy loads. The use of water is not advisable in this engine, but neither is an overload advisable. Nevertheless, in a pinch the water is useful and will do no harm other than increasing cylinder wear.

Versailles, Mo. R. MOSER.

In reference to the letter of A. S. Gabler I have this to say for his information and assistance;

It is characteristic of the dry type of engine to pound when loaded at or near its capacity and to "die down" when overloaded. The pounding is due to two conditions as a rule. One is early injection of the fuel, particularly with a light fuel, and the other is the fact that this is a dry engine—that is, one having no spray water injected into the cylinder to absorb the excess heat and consequently soften the pounding due to the first condition. As the engine approaches its load capacity, it is unable to get rid of the excess heat through the exhaust and the cylinder jacket water with the result that the piston becomes overheated and expands to the point where it binds the walls of the cylinder, resulting in additional pounding, in the wrist-pin and crankpin bearings. The engine then slows down, the governor opens up the pump stroke to care for this and makes matters worse by injecting an excess of fuel just when it is not wanted, creating more heat. Then, as something has to happen, the engine "dies down."

While the operator is getting his torch ready, this excess heat is being radiated through the jackets and to the air from the piston. This does not take very long; the piston is soon free again and easy to move, and the engine goes on as if nothing were out of the way.

The only real and lasting solution of Mr. Gabler's problem is to stop overloading the engine, but since I am going through with the same condition, I know that is a practical impossibility unless he can get another engine for his plant. The next suggestion is that he shorten his fuel-pump stroke to the point where his engine will just maintain full speed under normal load and then allow the load to govern it when overloaded. Of course, this will cause the lights to be dim, but that cannot be avoided with an overloaded engine of this type, and I find that the public would rather have dim lights continuously than intermittent lights.

He will find that this adjustment will cut down some of the excess heat and carbon deposits and lessen the frequency of his exhaust-pot burnouts. It will also help if he will clean out the exhaust ports frequently.

The extra lubrication seems to help the engine because it serves to carry off some of the excess heat from the piston and consequently delays the expansion of the piston to the binding point. F. C. WILLIAMS.

Ranger, Texas.

Having experienced "grief" similar to that of Mr. Gabler, I am sure his trouble with the 25-hp. semi-Diesel engine lies in overheating. While overheating may be caused in this engine by late fuel injection, the symptoms described by Mr. Gabler would rather indicate insufficient circulation of the cooling water or scale-coated cooling surface. Smoky exhaust will result from overcharge of fuel, but the pounding and dying down seem to indicate overheating.

It will be readily understood that when the cylinder is very hot the first part of the air charge expands and fills the combustion chamber with a very light charge of thin air, which does not contain enough oxygen for complete combustion of a full charge of fuel; therefore the unburned fuel leaves the exhaust in the form of smoke rather than in the form of the products of good combustion.

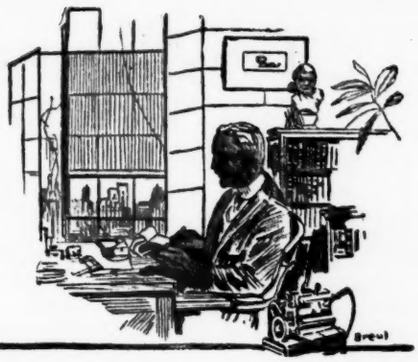
The pounding is caused by the charge being *exploded* by the excessive heat, whereas under a normal ignition temperature a more gradual and more complete combustion takes place.

I would suggest that the water jacket be thoroughly scaled and the lubricator slowed down to normal, for over-lubrication will cause a carbon deposit and aggravate the overheating, although a copious supply of lubricant will temporarily help by forming a seal between the piston and the cylinder wall, especially if the cylinder be worn or the rings "set" by a carbon deposit.

Olden, Tex. GEORGE B. MCCLELLEN.

Coal for power generation will be replaced so far as possible by the use of peat in the electrification of railroads in the vicinity of the large German cities, according to *Electric Traction.* Great hopes are being placed on the new Theissen 10,000 hp. vertical gas turbine, two of which have been ordered for use on the German railways. It is hoped that they will be able to replace the coal-burning locomotives. The peat bogs at Osnabruck will furnish the fuel.

INQUIRIES OF GENERAL INTEREST



Water in Crankcase of Semi-Diesel Engine—What causes water in the crankcase of a vertical semi-Diesel oil engine? B. R.

If the water enters the air passage, some will drip down into the crankcase. Often on vertical engines, heavy charges of water will, in this manner, flow down along the piston.

Inclination for Horizontal Return-Tubular Boiler—How much should a horizontal return-tubular boiler be set lower at the rear than the front end? W. L.

To facilitate drainage to the blowoff and insure submergence of the tubes at the rear end, the boiler should be set with a pitch of about $\frac{1}{16}$ in. per foot toward the rear end.

Benefit of Heavy Flywheel—What effect has the weight of a flywheel on the speed regulation of an engine? R. M.

The main purpose of a flywheel is to regulate the speed of an engine during one cycle by controlling the minor fluctuations due to uneven effort or resistance, and a heavy flywheel materially assists the governor in speed regulation by retarding the fluctuations in mean speed and giving the governor time to act.

Disadvantage of High Vacuum for Reciprocating Engine—Why is it not economical to try to maintain a high vacuum, say 29 in., for operation of a reciprocating engine? J. H. V.

In addition to the increased cost of operation, particularly from leakage due to greater difference of pressure on opposite sides of valves and piston, and increase of air leaks in the condenser connections, a very high vacuum is objectionable, as it increases cylinder cooling, causing greater loss from condensation that must be made up by supplying the engine with additional steam. The increase in operating cost becomes greater than the benefit obtained by reduction of back pressure.

Use of Double-Ported Valves—What is the object of a double-ported valve? C. D. F.

A double-ported valve is employed for the purpose of obtaining the desired area of port opening with small movement of the valve. Cylinders of large size require ports of considerable width, and with single port openings, the necessary travel of the valve becomes excessive. Other things being equal, the work required to actuate the valve varies directly as the travel. The double-ported valve gives twice the steam opening of an ordinary valve with the same travel and therefore is much used for large cylinders. For Corliss engines, large and quick port openings are needed where the engines are operated at the highest speeds, particularly for long range of cutoff, and to meet the requirements double-ported valves are used.

Economy of Direct-Acting Steam Pump—Why are direct-acting steam pumps, such as used for boiler feeding, so much less economical of steam required per horsepower-hour than most types of steam engines? L. K.

In pumps of this kind the load is constant during the whole stroke and it is impracticable to obtain the benefit of expansion of the steam by cutting off. With cutoff there is an excess of energy during the first half of the stroke and a deficiency during the latter half of the stroke, requiring storage and redistribution of the energy, as by employment of a flywheel. The piston of a direct-acting pump without any such device would stop the moment the steam was cut off, except, perhaps, in fast-running pumps with heavy reciprocating parts, where it may be possible to operate with cutoff a short distance from the end of the stroke, depending on the momentum of the reciprocating parts to carry the piston to the end. But in ordinary pumps for general service, this is not practical, and steam must be admitted the full length of the stroke and exhausted into the atmosphere or condenser at high pressure with great waste of steam.

Steam Discharged to Atmosphere Through Three-eighths-inch Orifice—What quantity of steam at 90 lb. gage would be discharged to the atmosphere, per hour, through an orifice $\frac{3}{8}$ in. diameter? P. G.

When the final absolute pressure is less than 0.58 of the initial, the discharge given by Napier's formula is accurate enough for most calculations; namely:

$$w = \frac{p \times a}{70}$$

where w = flow in pounds per second; p = initial absolute pressure of the steam, pounds per sq. in., and a = area of the smallest section of the nozzle or orifice in square inches. Having an initial pressure of 90 lb. gage, or 90 + 14.7 = 104.7 lb. per sq.in. absolute, and area of orifice equal to $\frac{3}{8} \times \frac{3}{8} \times 0.7854 = 0.11045$ sq.in., by substitution the formula becomes,

$$w = \frac{104.7 \times 0.11045}{70} = 0.1651 \textit{ lb. per sec.},$$

or a discharge of $0.1651 \times 60 \times 60 = 594.36$ lb. of steam per hour.

Relative Steam for In-Stroke and Out-Stroke—Which stroke of an engine should be supplied with more steam? F. S. B.

In an engine without a tail rod, the volume of piston displacement and the effective area of the crank side of the piston are less than for the other side on account of the presence of the piston rod. For the same work a higher mean effective pressure will be required for the stroke from the crank end, requiring somewhat longer period of admission, although with other conditions equal, for the same work, each end will require practically the same quantity of steam. But on account of the angularity of the connecting rod, more degrees of rotation of the shaft are accomplished while the piston is in the crank-end half of the cylinder, and the work in performance of rotation will be more uniformly distributed by admission of more steam for the stroke from the crank end than from the head end of the cylinder. With a vertical engine, more steam should be admitted on the up-stroke to compensate for lifting the weight of the piston and attached reciprocating parts, in addition to the quantity admitted for more uniform distribution of the rotative effect.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

Low-Temperature Distillation of Coal in Rotating Coke Oven*

By DIREKTOR DR. ING. E. ROSER

IN PRODUCER-GAS plants gasifying coal, the temperatures in the different zones do not remain constant. The producer frequently has to be stoked, unequal size of coal causes rim firing, parts of undistilled coals enter the gasification and even combustion zones, before being distilled or gasified. All these circumstances make it impossible to produce light carbureted hydrogens in producer-gas plants, even if they are run slow and cold. The great increase in the output of tar at low-distillation temperatures points also to the fact that, when distilling in a gas producer, the yield of tar depends to a great extent on the temperatures prevailing in the distillation zone. The output of tar is much lower when distilling the coal in a gas producer than when treating it in the rotary oven at low temperatures.

To make almost entirely available the bitumen contained in the coal in its primary condition, the author of this report started to commercially develop the process of separated distillation and gasification in two separate apparatus. After a number of trials a distillation oven in form of a rotating oven, such as shown and used for the manufacture of cement, was designed, constructed and installed by Thyssen & Co., A. G. Maschinenfabrik. The rotating oven was chosen on account of the favorable experiences with the produced half-coke, which proved well suited for the gasification in gas producers. This first trial plant with an output of 50 tons has been continuously working since the middle of 1919. The simplicity of the rotating coke oven in design, construction and running conditions has proved to be the best solution in every respect. The use of the rotating coke oven for the distilling of carboniferous materials is in principle well known.

The coal is distilled in a rotating oven similar to those used in cement mills. The low-temperature tar is reported to yield 90 per cent of the bitumens in the coal as against 50 per cent under present methods. The "half-coke" residue is said to be suitable for use on mechanical stokers. Experiments show that so far about 8.5 per cent more electrical energy may be obtained by using gas engines or gas turbines as well as oil engines and by thoroughly using the byproducts, than is obtained by direct coal firing and steam-turbine service.

Results Obtained in a Rotating Coke Oven

When distilling one ton of raw gas coal of the Gewerkschaft Friedrich Thyssen, Lohberg, in the rotating coke oven, the output was on an average:

Tar free from water (10 per cent), 100 kg. (220 lb.).

Uncleaned light oils extracted from the distillation gases evaporating up to 200 deg. C. (392 deg. F.), (3.0 per cent), 30 kg. (66 lb.).

Distillation gases up to 9,000 cal.

Lower heating value, in the average about 7,000 cal.[1] of the following composition:

CO_2	C_nH_m	O_2	CO	H_2	CH_4	N_2
Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
6.3	10.6	2.0	4.6	0	64.6	11.9

about = 150 cu.m. Half-coke, after deducting the amount of heat necessary for heating and rotating coke oven, about 650 kg. (1,430 lb.).

HEAT BALANCE OF THE LOW-TEMPERATURE DISTILLATION IN THE ROTATING OVEN

1 ton of raw gas coal of the Gewerkschaft Friedrich Thyssen contains about ..... 6,800,000 kg. per cal. (26,928,000 B.t.u.)

After deducting the amount of heat necessary for the heating of the oven, the following amounts of heat, chemically bound, are carried away with:

150 cu.m. (5,296.5 cu.ft.) of distillation gas (7,000 cal. (27,720 B.t.u.) per 0 deg.), about	1,050,000 kg. per cal.
100 kg. (3,531 cu.ft.) of low-temperature tar (8,600 cal. per kg.), (31,680 B.t.u.), about	860,000 kg. per cal.
650 kg. (1,430 lb.) half-coke (6,000 cal. per kg.), about	3,900,000 kg. per cal.
30 kg. (66 lb.) light oil (10,000 cal. per kg.), about	300,000 kg. per cal.
Total calories of heat chemically bound, about	6,110,000 kg. per cal.

Thermal efficiency of a low-temperature gas plant—

$$\frac{6,110,000}{6,800,000} \times 100 = 90 \text{ per cent approximately}$$

The half-coke can be gasified in gas producers as well as burned on stepped grates under boilers. The briquets made from the half-coke will be welcomed in households. The half-coke can well be briquetted. Pitch needs much less to be added than is required for briquetting slack coal.

Dr. Wittfield proposed to gasify all coal required by the state railway in Prussia, which in 1913 amounted to 11,000,000 tons, in the whole of Germany to 17,000,000 tons.

The briquetted half-coke could be burned in locomotives and the oil utilized in oil engines. By doing this the heat and coal efficiency in the railway service would be a much better one, the supply of illuminating gas to the cities and towns more reliable than up to now. The railways are bound to have their coals, as the traffic has to be carried on. If the whole amount of coal used by the railways should be distilled in this way, illuminating gas for about 25,000,000 people would be obtained, and in consequence, the consumption of coal by the gas works would be correspondingly less.

When distilling fuel of less value, coal dust, etc., the rotating coke oven would be a suitable apparatus on account of its simplicity and reliability.

Half-Coke and Distilled Gas for Power Purposes

Even more than in 1918 the sentence is still valid that "power engines without being connected to a byproduct recovery plant, cannot any more be considered, according to the actual state of the technique, as being the most advantageously and economically working power machines." In addition to this there is to be considered the fact that the price of coal will again be raised shortly.

The cost of production of a kilowatt-hour will be considerably less when distilling the coal in the rotating coke oven and afterward burning or gasifying the half-coke or burning the briquets made in gas producers or under boilers, as compared with gasifying the coal or burning it directly. It is also of importance that even the small manufacturer will be able to distill in a rotating coke oven the coal required and so recover the tar before burning the coal under boilers.

The following tabulation shows that there is no higher consumption of coal when recovering the byproducts, gasifying the half-coke and using the gas in gas-engine or turbine power plants. In the power service of large industrials, owing to the use of gas engines or gas turbines as well as oil engines, and through entirely utilizing the byproducts, 1,392 kw. against 1,280 kw. are obtained by direct coal firing and steam-turbine service; that is to say,

*Abstract of a paper by the author in *Stahl und Eisen*, Düsseldorf, Germany.

[1]The B.t.u. equivalent of the kilogram-centigrade calorie is 3.96. The large or kilogram-centigrade calorie is the heat necessary to raise 1 kg. of water 1 deg. C. The kilogram equals 2.2 lb. and one degree centigrade equals 1.8 deg. F., therefore 1 × 2.2 × 1.8 = 3.96.

about 8.5 per cent more kilowatt-hours can be generated from one ton of coal.

When in steam power work the steam boilers are fired by gas from gas producers, and when the distillation gas, free from tar, is added to the producer gas, then, out of one ton of coal about 25 per cent less kw.-hr. will be produced than by direct coal firing. The exploitation of such products as grease, paraffin and pitch when making use of the rotating coke-oven process, is not here considered.

Utilization of Coal in Power Works

Steam-power installation: Out of one ton of gas coal of the Friedrich Thyssen-Gewerkschaft can be produced in modern power plants with steam turbines at full load:

By direct firing of the coal under the boiler:

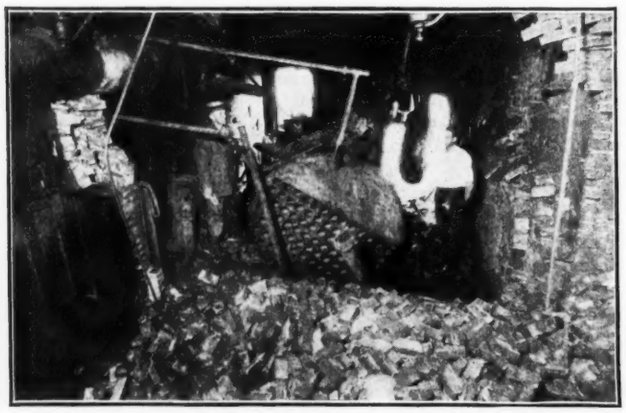
$$\frac{1000 \cdot 7000}{5450} = \ldots\ldots\ldots\

A Typical Low-Water Boiler Explosion

At 6:57 a.m. Oct. 5, a boiler exploded at the plant of the Wellington Machine Co., Wellington, Ohio, killing two and injuring one, four others having a narrow escape. The property loss was from seven to ten thousand dollars.

The boiler was a three-ring horizontal return-tubular type of lap-joint construction, 72 in. in diameter by 16 ft. long, having 80 four-inch tubes. It was built in 1904. On Jan. 25, 1920, when the last internal inspection was made by a qualified inspector, the boiler was found in good condition and granted a certificate for 100 lb. working steam pressure.

About 5:20 on the morning of the explosion the engineer, Fred Burton, who had carried a third-class Ohio license since 1905, arrived at the plant and broke down his fire, which had been banked from the night before. Together with several other employees, he fired the boiler for some thirty minutes without any apparent results toward getting up steam, the gage registering only a few pounds. He, then, as the result of an afterthought, looked at his water glass and discovered that his water was gone. He next attempted to start the boiler-feed pump, but owing to the



BOILER ROOM SHORTLY AFTER EXPLOSION

low pressure in the boiler, it was very sluggish. He then returned to the front of the boiler and started to get his scraper to pull the fire. At this moment one of the factory employees who was in the boiler room noticed the pointer on the steam gage rise to about 80 lb. and started to remark that everything was all right, he now had plenty of steam; but as he started to say "steam," the explosion occurred, the result of which tore down the boiler setting and moved the rear of the boiler about four feet and the front six feet to the right, tore out a brick wall between the boiler room and the factory and generally wrecked the adjoining brick walls. The rest of the factory was not injured to any great extent.

At the time of the explosion there were seven men in the room, which was not very large and contained not only the boiler, but also the engine, pump and heater. The engineer was buried under the boiler front and some brick work and although still alive when removed, died on the way to the hospital. George Whitney, was standing in the passage way between the engine and boiler wall and was buried beneath the boiler and brickwork and literally roasted alive by the brickwork and hot boiler. Frank Rowell received a fractured leg, and the others escaped with a few slight scratches and bruises, and were able to be at work the next day.

Fred Edwards, master mechanic of the Wellington Machine Co., made the statement that upon arriving at the plant about twenty minutes after the explosion, he found the boiler and boiler tubes still red-hot.

All the information herein was gathered from records and interviews with the survivors.

As the result of an inspection of the exploded boiler, the following facts were gathered: The entire shell exposed to the fire and all the tubes showed that they had been red-hot, all soot and other matter having been burned from them, giving the metal the well-known appearance which results from overheating. The initial rupture was about six feet long, extending the length of the middle course a little to the left of the bottom. The edges of the sheet were reduced to almost a knife edge, due to the pulling apart of the metal, which had been heated until quite soft. The girth joint between the first and second courses was opened up about three feet, but no rivets had been sheared, the sheet having pulled away from rivet shanks. There was also a little to the right of the large rupture another opening in the shell about four inches long, and extending for several feet to each end of this the sheet was drawn almost in two, indicating that if the boiler had not opened up where it did, it would have opened at this point.

An inspection of the wreckage confirms the belief that the explosion was the result of the fallibility of man. Had the engineer learned and applied the first duty of an engineer upon entering a boiler room (ascertain the condition of the water in the boiler), this accident would not have occurred. Another fact was brought out by this accident, and that is that had the boiler been provided with a fusible plug as is always recommended by the Ohio Boiler Inspection Department, but not required on boilers installed previous to the enactment of the boiler inspection law, the accident would not have occurred, for in that case the melting of the fusible plug would have given warning to the engineer and would have relieved the pressure to such an extent that the pump would not have responded at all.

The object of this report is not to criticize the engineer or any other person concerned either directly or indirectly, but to put forth the facts which may at some future time save the destruction of life and property.

The Inspiring Outlook for American Engineering*

By Morris Llewellyn Cooke

The hour of opportunity for the engineering profession really seems to have arrived. All the problems of our common life have come to be recognized as of a size and complexity requiring basic solution. On the one hand we see indications that the public is beginning to lose faith in short cuts and political expediency and will more and more demand social and economic readjustments based on a full understanding of all the facts and a thorough-going orientation of all the elements in any given situation. On the other hand, there is clearly discernible throughout our profession a growing sense that somehow the engineering approach is what is needed if ordered progress is to be the watchword for a civilization in the agonizing process of seeking new levels. Every day sees us ready to broaden our definition of engineering. To the fields of design and construction we are adding operation with ever-increasing emphasis. No one has stated this expansion in the scope of the field of our profession in a more illuminating fashion than Herbert Hoover, when, in speaking of the engineer, he said:

> Unlike the doctor, his is not the struggle to save the weak. Unlike the soldier, destruction is not his prime function. Unlike the lawyer, quarrels are not his daily bread. Engineering is the profession of creation and of construction, of stimulation of human effort and accomplishment.

Such a job is certainly there to be done. Even if we have not been officially tagged or designated to do it, we must admit that there is no other agency or division of society competing with us for the opportunity to do it. It therefore comes down to the question of our capacity to embrace an opportunity as splendid as it is obvious. Are we ready for it? And what must we do further to prepare for it?

In the first place, our efforts must be coördinated, first into societies, then into a national unit, and ultimately throughout the world. We have long had our engineering

*Abstract of a noonday luncheon talk before *The Philadelphia Engineers'* Club, Oct. 19, 1920.

societies, and we have been revamping them and developing them in recent years. We are now organizing our Federated American Engineering Societies, which form the national unit. The international aspect of the case is part of our future problem. The development of engineering solidarity will be impossible, however, except as we break down the distinctions between men practicing in different branches of the profession. This will require a high spirit of broadmindedness and co-operation.

Our current schemes of organization of engineering bodies—our management, administrative and directive methods—are all very crude, permit much duplication of effort and anxiety over non-essentials. In the light of historical development perhaps it could not be otherwise. But in view of the fact that management and its allied activities are now a recognized part of engineering, it behooves us to study the problems of our own organization. We should be a model in this respect for other social agencies.

Cultivation of Imagination

Perhaps the highest attribute of an engineer is imagination; and yet you will look in vain for a course in engineering where a conscious effort is made to cultivate the imagination of the student. Fortunately, however, those in charge of technical and engineering education have come to understand this, and the trend of the times is to devote a little more attention to humanistics and the engineering of men.

In a world where nothing but moral values really count, we must introduce something akin to spiritual values into engineering. Any possible difficulty in the way of working out a satisfactory code of ethics for engineers is removed when as in the new draft of the American Society of Mechanical Engineers and in the constitution of the Federated American Engineering Societies the public interest is recognized as the supreme test of professional conduct. If a given act is not, broadly speaking, conducive to the public welfare, it is no longer good engineering. Thus the master step has already been taken.

Nothing can be truly great unless it is beautiful. The cultivation of esthetics as a feature in every branch of engineering must be insisted upon. Sometimes we associate noise and ugliness and even filth with accomplishment—with "getting things done," as we say. This is wrong. Largely because we need the influence of their love of the beautiful, we should try to get closer and closer to the architects so that ultimately we may find ourselves one profession.

Spirit of Democracy Must Be Developed

Last but most important of our needs is the development of the spirit of democracy in every nook and cranny of our organization. We must not discriminate against the young man simply because he is young. We must adjust ourselves to the entrance of women into full participation in public affairs. We must further develop the idea of engineering home-rule; even the national organization will profit by strong, even self-assertive local units. Finally, nothing promotes genuine democracy so effectively as publicity. Hence we should be grateful to the sponsors of the new Federation who provided in Article X of its Constitution: "This organization shall stand for the principle of publicity and open meetings." This puts our profession clearly in advance of all others on this very important point. It is significant that, recently, two engineering organizations numbering over 30,000 members published at the head of the correspondence columns in their official publication a pledge to publish in whole or in abstract any communication contributed by a member. Let us study the technique of reaching the people through non-technical publications, and throw open our engineering laboratories, libraries and halls to the widest possible public use. Let us seek to have engineering grow up, as it were, out of the necessities and desires and life of the people.

These are the steps by which alone we shall be able to fulfill our obligations to science and to humanity. In Mr. Cooke's own words, "It is to the largest possible fulfillment of this inspiring task that we dedicate our lives."

Hartford Section of A. S. M. E. Discusses the Superstation

The Hartford Section of the American Society of Mechanical Engineers held its first meeting of the season on Monday, Oct. 18, the subject being The Superstation, and the speaker being John A. Stevens, of Lowell, Mass. Mr. Stevens in his opening remarks complimented Hartford as being the first American city in which a steam turbine of any considerable size was installed, the city in which the first boiler-insurance company was organized, the city in which group insurance was conceived, the city in which the first turbine to be driven by mercury vapor is being installed, and the first city to call a meeting for the specific purpose of discussing the superpower station. He reviewed the advantages of a system of inter-connected stations, such as is in contemplation for New England and the Middle States, and predicted the time when the power of New England would be concentrated in five great stations. He pleaded the bigger view and larger vision which would lead to the consideration of the power problem as a whole, and the avoidance of the many diversities of practice as to voltages, frequencies, etc., which led away from unification. A large part of his address was devoted to a description of the superstation designed in panels of 30,000 kw. capacity by himself and his associates, and described in recent issues of *Power*.

Mr. Stevens' remarks were listened to with evident interest by an audience which completely filled the auditorium of the City Club, and his pressing invitation to discuss the merits of the plan proposed, and beat it if possible, led to an interesting discussion which took, however, rather the nature of a quest for further information than of specific criticisms of the plan advanced. Without attempting to particularize the individual speakers, the discussion brought out that the feeling of insecurity which purchasers of power had had when depending upon a distant source of power was being dispelled by the generally satisfactory character of the service. Mr. Stevens said that one of his own plants takes power from a source 75 miles away. Asked about auxiliaries, Mr. Stevens said that he preferred such a combination of electrical and turbine-driven auxiliaries as would permit enough of the steam-driven units to be operated to preserve the heat balance. Another inquiry brought forth that the estimated coal consumption of the proposed superstation was 1.11 lb. of coal having a thermal value of 14,000 B.t.u. per kw.-hr., which could be reduced to 1.085 by preheating the air and other modifications. This with a power factor of 80 per cent. In reply to an inquiry as to whether preheating the air was likely to work an injury to the stokers, the speaker replied that it was contemplated to raise the temperature of the air to only about 170 deg. instead of to the high temperatures in use abroad with the Howden and other systems. The smaller amount of heating would produce an additional economy of 2.35 per cent.

As regards the use of steam-driven stations as standbys, or as major sources of power, in connection with hydroelectric developments, Mr. Stevens believed that all the water available should be used all the time. It is essential that every possible pound of coal should be saved. Bleeder turbines should be used in the central station only for heating feed water, but it had a wide use in industrial plants in furnishing steam for heating and manufacturing processes. One should not, however, go crazy on that score and put a power plant into a church for the purpose of getting exhaust steam to heat it once a week.

The question of tying existing isolated plants into central station distributing lines was discussed, and Mr. Stevens said that this was done successfully in some places. In St. Louis 65 or 70 such plants were tied into the central station system, which furnished such plants with power in the summer when there was no use for exhaust steam, while in the winter they were operated at capacity, supplying exhaust steam for heating and surplus power to the system.

Hiram P. Maxim, of Silencer fame, who had been industriously figuring during the discussion, said that he had produced some figures that astonished him. A station of

250,000 kw. capacity would use, even at the rate of 1 lb. of coal per kw.-hr., 125 tons of coal per hr., or 3,000 tons per day. This would amount to 1,095,000 tons a year, or 91,250 tons of coal a month, and the five stations, if run at capacity, and at this rate of consumption, would require 456,250 tons of coal a month, which would require the bringing into New England for this purpose alone of 22,812 loaded coal cars, assuming each car to carry 20 tons. A member pointed out, however, that the gondola cars now in use carry 50 tons. Mr. Maxim asked Mr. Stevens if this was what he thought we were coming to, and Mr. Stevens replied, "Not next year, but in the future."

Mr. Maxim wanted to know if it were possible to get away from the transportation of all this coal by the use of Diesel engines, and Mr. Stevens said that this was one of the "ifs," but that the oil fuel should be reserved for marine purposes. There are 300,000 kw. installed capacity within a radius of 50 miles of Newburyport. A great deal of coal is used by the railroads themselves in transporting the coal and other freight. He had been told within a day or two by an eminent railroad engineer that the railroads will be electrified in and near the cities within a short time, but that he doubted if it would ever come for trans-continental traffic. In seventeen years all the oil will be exhausted. For power generation it is coal.

Mr. Jeter, of the Hartford Steam Boiler Inspection and Insurance Co., always with an eye to accident prevention, said that it was a good thing to get away from the use of oil. Only a few years ago the papers were full of accidents from the explosion of kerosene lamps. Today one never hears of them.

A member inquired whether this wasteful transportation of coal could not be avoided by locating the superpower plants at the coal mines and using cooling ponds or towers for condensing water. Mr. Stevens replied that for work of this magnitude it was out of the question. The sacrifice of the high vacuum, unattainable by artificial cooling, and the cost of pumping and maintenance, is prohibitive. One case which he had investigated would have required a cooling pond 2,600 ft. long and 180 ft. wide. It would have fogged the country for miles around, and have required a good-sized brook for makeup water. Samuel Ferguson, president of the Hartford Electric Light Co., said that the station in Hartford requires at the present time four times as much water as is used by the city itself.

At the next meeting of the Section on Nov. 5 Prof. Arthur M. Greene, Jr., of Rensselaer Polytechnic Institute, will lecture on The Development of the Pumping Engine.

Sespe River Project to be Financed

The Sespe Power Corporation, which plans the construction of five hydro-electric power units on the Sespe River, Ventura County, Cal., has been authorized by the railroad commission to issue $2,000,000 of bonds and $1,000,000 of its common stock to secure funds with which to carry out its development program. The company asked for a $3,000,000 bond issue. None of the money raised by the stock and bond issue is to be expended, however, until there are sufficient funds on hand to construct the plant expeditiously.

In the event that the company is unable to finance the project, the money is to be returned to the stockholders, less such an amount as may be allowed by the commission for expenses.

Among the restrictions governing the financing of the proposed new utility is one requiring that for every $1,000 bond sold the company must sell concurrently at least $1,000 of stock at par.

The Sespe company's estimate of construction costs totaled $3,722,748. The commission's engineers say this figure is entirely too low. Their estimate is $5,500,000. The corporation's estimate of output, 197,926,017 kw.-hr., is not concurred in by the commission's engineers, who hold that only an average annual output of 75,000,000 kw.-hr. can be depended upon.

The company is authorized to enter into an agreement with the Southern California Edison Co. to sell to the Southern company the output of the hydro-electric plants.

To Supply Oil to Shipping-Board Vessels on Pacific

As a result of bids received, award has been made to the Standard Oil Company of California, under date of Sept. 23, for supplying lubricating oil requirements of all Shipping Board vessels at Pacific Coast ports and Honolulu. Deliveries are to begin under this award Oct. 24 and to continue for a period of one year from that date. All bids received for supplying lubricating oils at Atlantic and Gulf domestic ports were rejected, and tenders will shortly be reinvited.

The prices per gallon in wooden barrels ranged from 52 to 56 cents for steam-cylinder and for superheat-cylinder oil; from 31 to 35c. for ice-machine cylinder oil; from 61 to 65c. for marine-engine oil for all wick- and sight-feed systems; from 33 to 37c. for light oil for forced feed; from 33 to 37c. for medium oil for forced feed and turbine-reduction gears, and from 46 to 50c. for heavy oil for turbine-reduction gears. The prices on marine-engine oil for wick- and sight-feed systems, as given, were approved with the option of substituting Polar marine-engine oil at six cents per gallon less. If wooden barrels are returned, allowance of one dollar each is given. If delivered in five-gallon cans in wooden cases, prices are five cents higher on all items. If delivered in iron barrels to be immediately returned, prices are five cents lower on all items. The total requirements are estimated to be 371,716 gal., to cost $195,808.30.

Coal Association Predicts Early Relief

The Executive Committee of the American Wholesale Coal Association, at a recent meeting in Washington, made a thorough canvass of the present coal situation. As a result it feels justified in advising members of the Association and the public generally on the following points:

1. The American people some months ago were of the opinion that there was danger of an impending shortage of bituminous coal. The satisfactory production since July 1 has proved this momentary alarm to have been unfounded.

2. Abnormally high prices were paid by the consumers while they were animated by the fear of possibly impending famine. These prices are now placed wholly out of line by the quite satisfactory production.

3. For a while many restraints were put upon distribution of bituminous coal, with the result that retail dealers were unable to fill urgent orders. Since the supply promises to be abundant, there is no reason for continuing any such restrictions. Due allowance should be made by the public for the fact that this statement relates only to soft coal and for the further fact that retailers cannot do all of their normal winter business in a month or two. They have not and cannot get the equipment necessary to such a feat even if they could get the coal.

It is the opinion of the committee that a great change in the whole market situation is imminent. Therefore, it suggests to buyers of bituminous coal who have a month's supply in storage that they confine purchases to immediate needs.

Petroleum Data for August

The Geological Survey figures show that for August, 1920, the total consumption, including exports, of domestic and imported petroleum was 47,814,000 bbl., while the production of domestic oil fields was 39,144,000 bbl. Imports in the same month reached a new high record, 10,790,686 bbl., making a total of domestic production and imports of 49,934,686 bbl.

It will be seen from these figures that the domestic production of crude oil in August was more than 8,000,000 bbl. below the actual consumption. The imports, however, were so great that stocks of imported oil held in the United States increased in this month by about 1,250,000 bbl. It should be borne in mind that all this imported oil is of very low gasoline content and does not, to any great extent, increase the available marketable supply of gasoline.

Plans Are Completed For New Cedar Falls Power House

The completion by the city architect on Aug. 25 of plans and specifications for the new Cedar Falls power house designed to accommodate the necessary machinery to develop 20,000 hp. additional marks the last step preparatory to beginning actual construction work on this much needed unit, which is to cost $1,000,000.

The new concrete and steel structure will adjoin the present power house below the falls and is to house a Pelton overhung turbine connected to a Westinghouse generator and to Allis-Chalmers transformers, which will bring the current up to 60,000 volts. This is the first generating unit of large size to be installed under the new system designed by Superintendent of Lighting J. D. Ross, by which the generating unit and transformers are considered as an inseparable unit without intermediate switches and busbars as is found in all other plants. The same system will be used at the Lake Union steam plant and is to be used by the Detroit-Edison Co., of Detroit, one of the largest electrical engineering firms in the world, in its future installations.

Personals

Harry B. Joyce, formerly power engineer of the United Electric Light and Power Co., New York, has joined forces with Johnson & Benham, Inc., Engineers, 150 Nassau St., New York.

A. F. Elliott, formerly chief electrician in the Coal Mining Department of the Tennessee Coal, Iron and Foundry Co., has been appointed general master mechanic for the Sloss-Sheffield Steel and Iron Co., of Birmingham, Ala.

J. C. Stevens and R. E. Koon, consulting engineers, have consolidated under the firm name of Stevens & Koon, with offices in the Spalding Building, Portland, Oregon.

D. Tarshes, formerly with the Walworth Manufacturing Co., Boston, and the Best Manufacturing Co., Pittsburgh, is now the New York, New England and Eastern Canadian representative of the M. J. Dougherty Co., piping fabricators and erectors, of Philadelphia. Mr. Tarshes is located at 23 West 43rd St., New York City.

Society Affairs

The Cleveland Engineering Society will hold open house for all members and their friends, election night, Nov. 2, and will have the latest Election Returns.

The Detroit Engineering Society is to hear a talk Nov. 5 on "Conditions in Europe from a Political, Social and Engineering Standpoint," by E. J. Mehren, editor of *Engineering News-Record*, who recently returned from an extensive trip through Europe.

The Buffalo Section of the A. S. M. E. will meet on Oct. 26, at the University Club. S. T. Dodd, of the General Electric Co., will speak on "Steam Railroad Electrification." Preceding the meeting, which will be at 8 p.m., an informal dinner will be served at 6.30.

The Philadelphia Section of the Association of Iron and Steel Electrical Engineers will meet Nov. 6 to hear addresses on "Electric Heat Treatment, Present Practices and Future Possibilities." The speakers will be: George P. Mills, of the Electric Furnace Construction Co., Philadelphia, Pa., J. R. Bower, of the American Car and Foundry Co., Berwick, Pa., and James E. Wilson, of the Treadwell Engineering Co., Easton, Pa.

The American Society of Mechanical Engineers has recently organized two new sections. One, the *Aeronautic Section*, was started with the purpose of promoting in a large way the broad engineering development of aërial navigation regarded as an essentially international science, art and business. Among those who have registered in this section are Howard E. Coffin, Jesse G. Vincent, Orville Wright, C. F. Kettering, Elmer A. Sperry, James Hartness, John R. Cautley, Lionel S. Marks, Miller R. Hutchison, Charles E. Lucke and Joseph A. Steinmetz. The other one, the *Materials Handling Section*, will devote itself to a solution of the various local and national problems of handling and distributing materials and products. The aim of its 400 members will be to build up a comprehensive fund of information by holding special meetings on particular subjects and by co-operation with other sections and organizations.

The American Institute of Electrical Engineers at a meeting of the Board of Directors held in Philadelphia, Oct. 8, decided to hold the 1921 annual convention jointly with the Pacific Coast convention, at Salt Lake City, Utah, during the week beginning Monday, June 20. At the same meeting the following twelve members were appointed as the official representatives of the Institute upon the American Engineering Council, which is the governing body of the Federated American Engineering Societies: Comfort A. Adams, Cambridge, Mass., A. W. Berresford, Milwaukee, Wis., H. W. Buck, New York, N. Y., F. L. Hutchinson, New York, N. Y., W. A. Layman, St. Louis, Mo., William McClellan, Philadelphia, Pa., L. F. Morehouse, New York, N. Y., L. T. Robinson, Schenectady, N. Y., Charles S. Ruffner, New York, N. Y., Charles F. Scott, New Haven, Conn., L. B. Stillwell, New York, N. Y., Calvert Townley, New York, N. Y.

Business Items

The Frederick Engineering Co., of Frederick, Md., has opened a district office at Chicago, 1247 Marquette Bldg., to place the company's automatic underfeed stoker and steam jet ash conveyor in this territory. Ralph W. Gillette will be the district sales manager.

Trade Catalogs

The Fuel Engineering Co., of New York, has brought out a booklet entitled "How Successful Manufacturers are Making Mechanical Power Produce More and Cost Less." This booklet describes in considerable detail the company's thirteen years' experience in raising the efficiency of various power plants.

The Bastian-Blessing Co., Austin Ave. at La Salle St., Chicago, claims to have developed a new principle in oxyacetylene welding and cutting, which is described in their catalog of Rego apparatus. This new equipment is said to be absolutely free from the usual flashback difficulty and to be economical in the use of oxygen.

Nonpariel Insulating Brick is described in a new 72-page book put out by the Armstrong Cork Co., Pittsburgh, Pa. The book is well gotten up and goes into great detail regarding the character of "Nonpariel" brick, tests that have been made upon it, various methods of using it and examples of actual use. It is illustrated with photographs, diagrams and a great many tables of interesting data.

The Dravo Co. of Milwaukee has issued a short bulletin containing photographs and diagrams which show the general construction and application of the Dravo superheater.

"The Petroleum Outlook" is the title of a short but comprehensive book just put out by Arthur D. Little, Inc., chemical engineers, 30 Charles River Road, Cambridge, Mass. It deals with the degree of exhaustion of our oil fields and the future outlook for them. The book will be sent free of charge to bankers, brokers, manufacturers and investors upon application.

New Construction

PROPOSED WORK

Mass., Hyde Park (Boston P. O.)—The City, Public Bldgs. Dept., is having plans prepared for a 3 story, 75 x 165 ft. building including a steam heating system on Everett Sq. About $350,000. Desmond & Lord, 15 Beacon St., Boston, Archts.

Mass., Springfield—The Bd. Educ. will receive bids until November 3 for a 3 story junior high school including a steam heating system on State St. About $800,000. Henry L. Sprague, 310 Main St., Archt.

N. Y., Brooklyn—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., received bids for an underground electric light and power distribution system at the Naval Hospital here from the General Electric Co., 22 Leight St., $26,435; Harry Alexander, 20 West 34th St., $31,530; Lord Electric Co., 105 West 40th St., $31,760. All of New York City. Noted Oct. 5.

N. Y., Brooklyn—The New York State Hospital Comn. will receive bids until December 10 for several hospital buildings here, including a steam heating system. About $3,000,000. L. F. Pilcher, Hall of Records, New York City, Archt. and Engr.

N. Y., Buffalo—The Delaware Vacuum House Cleaning Co., 150 Chenango St., is in the market for one 5-hp. gas engine.

N. Y., Buffalo—The Hub Dry Cleaning Co., 110 Grant St., is in the market for one 2- or 3-hp. vertical boiler.

N. Y., Central Islip—The State Hospital Comn., Capitol, Albany, will receive bids about February 5 for 2 asylum buildings here, including a steam heating system. About $350,000. L. F. Pilcher, Hall of Records, New York City, Archt. and Engr.

N. Y., Cortland—The State Bd. Educ., Capitol, Albany, will receive bids about January 2 for several buildings for the normal school including a steam heating system. About $1,750,000. L. F. Pilcher, Hall of Records, New York City, Archt. and Engr.

N. Y., Kings Park—The New York State Hospital Comn., Capitol, Albany, will receive bids about February 5 for 2 asylum buildings including a steam heating system. About $350,000. L. F. Pilcher, Hall of Records, New York City, Archt. and Engr.

N. Y., New York—The Bd. Educ., 500 Park Ave., is having plans prepared for a 5 story school including a steam heating system on St. Pauls Ave. near Washington Ave. About $400,000. C. B. J. Snyder, Municipal Bldg., Archt. and Engr.

N. Y., New York—The Chelsea Methodist Episcopal Church, c/o Polhemus McKenzie & Coffin, Archts. and Engrs., 15 East 40th St., plans to build a church including a steam heating system on 178th St. About $400,000.

N. Y., New York—The Lincoln School for Teachers, c/o Starrett & Van Vleck, Archts. and Engrs., 8 West 40th St., is having plans prepared for a 5 story, 100 x 150 ft. school including a steam heating system on 5th Ave. and 102nd St. About $1,000,000.

N. Y., New York—The Peoples Home Methodist Episcopal Church, c/o Polhemus, McKenzie & Coffin, Archts. and Engrs., 15 East 40th St., plans to build a church including a steam heating system at 542 East 11th St.

N. Y., New York—The State Hospital Comn., received bids for soot blowers and repairs to the heating system in the Manhattan State Hospital, from the Payer Steam Soot Blower Co., 11 John St., $5,700; Diamond Power Specialty Co., 30 Church St., $7,955.

N. Y., Penn Yan—J. T. Andrews & Co. plans to install 3 hydraulic turbines to replace present ones. C. R. Andrews, Operating Engr.

N. Y., Rochester—The Chocolate Shoppe, 11½ Clinton Ave., North, is in the market for a 12-in., 110-volt, alternating-current electrically driven blower.

N. Y., Rochester—Tatlock Bros. is in the market for one 50-hp. marine type boiler.

Pa., Bethlehem—The Traveler Rubber Co., 114 North Montgomery St., plans to build a 1 story, 25 x 35 ft. pumping house and a 20 x 30 ft. cement house. About $10,000. J. O. Hunt, Trenton, N. J., Archt.

Pa., Chester—The Stalium Metals Corp. of America, 226 Lafayette Bldg., Philadelphia, plans to build a plant including several buildings for the manufacture of stalium. A steam heating system will be installed in same. About $500,000. R. Beard, 2349 North Woodstock, Philadelphia, Archt.

Pa., Lancaster—The Edison Electric Co. of Lancaster and the Harrisburg Light & Power Co. of Harrisburg are planning to build a hydro-electric plant here, on the Susquehanna River, to generate an ultimate capacity of 100,000 kw.

Pa., Lansdale—The Borough Council has arranged to sell $50,000 bonds for the installation of additional equipment at the municipal electric light plant.

Pa., Philadelphia—The Engineering Gear Co., 430 Walnut St., is in the market for one Gleason generator.

Pa., Warren—The Struthers Wells Co., 1003 Penn. Ave., W., will soon award the contract for a 1½ story, 68 x 140 ft. forge shop and a 40 x 86 ft. boiler house. About $100,000.

D. C., Washington—The Methodist Episcopal Bd. of Temperance Prohibition and Public Morals, 204 Pennsylvania Ave., has had plans prepared for a 6 story office and apartment building. About $500,000. Ballinger & Perrot, 328 South Broad St., Phila., Pa., Archts. and Engrs.

N. C., Southern Pines—S. B. Richardson and A. S. Newcomb plan to build a resort hotel. About $275,000.

O., Canton—The Bd. Educ. received bids for a 3 story, 130 x 160 ft. school, including steam heating system on Grace Ave. from Geo. Whiker & Son, $296,500, and Melbourne Bros., Eagle Blk., Tuscarawas, West, $311,680.

O., Maple Heights (Bedford P. O.)—The Bd. Educ., c/o W. N. Blanchard, Pres., will vote on $300,000 bonds Nov. 2, for a 2 story school including a steam heating system, at Stop 11½. Architect not selected.

O., Zanesville—The Baltimore & Ohio R.R., Market and 2d Streets, is having preliminary plans prepared for an electrical plant and a new heating plant at the railroad shops on Lee St. About $300,000. H. A. Lane, Baltimore, Md., Engr.

Ind., Fort Wayne—The Fort Wayne Storage Co., Harrison and Grand Sts., plans to build a 6 story, 95 x 194 ft. storage warehouse at Francis and Hayden Sts. About $500,000. Moore & Dunford, First Natl. Bank Bldg., Chicago, Ill., Engr.

Mich., Detroit—Kassler & Sons, c/o S. E. Remey, Archt., Whitney Bldg., plans to build a 2 story, 30 x 150 ft. garage including steam heating system on Dix Ave. About $10,000.

Wis., DePere—St. Norberts College, Boyle Hall, is having plans prepared for a 3 story, 80 x 260 ft. science hall including a steam heating system. About $400,000. W. E. Reynolds, 113 South Roosevelt St., Green Bay, Archt.

Wis., Fond du Lac—The Sheboygan Dairy Products Co., c/o M. G. Douma, Mgr., 936 North Water St., Sheboygan, is having plans prepared for a 2 story, 120 x 300 ft. dairy products factory including a steam heating system and electric power on West Division St., here. About $100,000. B. E. Mehner, 6 East Division St., Archt.

Wis., New London—The Sheyboygan Dairy Products Co., c/o M. G. Douma, 936 North Water St., Sheboygan, plans to install equipment including ice machine, motors, pumps, mixers, etc., in its ice cream and dairy products factory, here. About $25,000.

Ia., Sioux City—The Bd. Educ., City Bldg., plans to build a 3 story, 130 x 130 ft. school, including a steam heating system, on 7th and Jackson Sts. About $250,000. H. C. Roberts, Secy. Beuttler & Arnold, 235 Grain Exch., Archts.

Iowa, Tama—The J. G. Cherry Co., E. T. Cherry, Vice Pres., had plans prepared for canal work and dam for a lighting system. Power Eng. Co., Metropolitan Life Bldg., Minneapolis, Minn., Engrs.

Minn., Aitkin—The Bd. Educ. is having plans prepared for a 3 story high school, including a steam heating system. Cost to exceed $400,000. A. Casey, Clk. K. T. Snyder, 738 Plymouth Bldg., Minneapolis, and H. S. Swanson, Crosby, Archts.

Minn., Chisholm—The Bd. Educ., c/o Ernest Drew, clk., plans to build a vocational school including a steam heating system. About $250,000.

Kan., Portes—J. E. Kissel, City Clerk, will receive bids until Oct. 26 for waterworks improvements, including a motor distribution system, etc. About $32,000. Noted Oct. 5.

S. D., Huron—Beadle Co. will receive bids until Nov. 16 for a 3 story, 92 x 108 ft. courthouse, and a 2 story, 31 x 53 ft. jail, including a steam heating system. About $400,000. W. E. Hulse & Co., 320 Grain Exch., Sioux City, Ia., Archt.

Tex., Kennedy—The Kennedy Oil Mill Co. has been granted a franchise for electric lights and power here, and will install machinery in connection with its oil mill.

Tex., La Porte—The La Porte Light, Water & Ice Co. plans to rebuild its plant recently destroyed by fire, causing a loss of $20,000.

Col., Sterling—The Great Western Sugar Co., University Park Siding, is having plans prepared for a factory near here. About $2,000,000. Edwin Morrison, Sugar Bldg., Denver, Engr.

N. B., Grand Falls—The International Paper Co., Three Rivers, Que., plans to develop water power here.

Ont., Almonte—A. F. Macallum, Engr., City Hall, has prepared report, estimate and preliminary survey for a water-works system, including pumphouse, etc. About $263,695.

Ont., Toronto—Cudland & Sons, 1450 Gerrard St., East, plan to build a 2 story meat packing factory, including refrigeration equipment. About $40,000. Archt. not yet appointed.

Ont., Windsor—Colthurst, Trace & Nichols, Archts., 16 Sandwich St., West, are preparing plans for a 2 story, 120 x 400 ft. cold storage plant. About $600,000. Owner's name withheld.

B. C., Vancouver—The Bridge River Power Co., c/o R. W. Bonnycastle, Engr., 606 Bank of Nova Scotia Bldg., plans to build a dam and a power house to develop a total of 400,000 kw., initial construction from 50,000 to 15,000 kw., and units of 25,000 kw. to be developed under a 600 to 700 ft. head.

CONTRACTS AWARDED

N. H., Lincoln—The Parker-Young Co., Lisbon, has awarded the contract for a 1 story power house here to the Osgood Constr. Co., 25 East Hollis St., Nashua, at $20,000.

Mass., Fitchburg—The Fitchburg Gas & Electric Light Co., 537 Main St., has awarded the contract for a 2 and 3 story, 58 x 152 ft., addition to plant, including a boiler house at Sawyer's Passageway, to Wiley & Foss, Central St., at $125,000.

Mass., Lynn—The General Electric Co. has awarded the contract for a 1 story, 35 x 40 ft. boiler house, to C. W. Wright, 23 Central Ave. Cost between $25,000 and $30,000.

Mass., Peabody—The City School Comn. has awarded the contract for the installation of a steam heating system in the proposed 2 story high school on Central St. to Stone-Underhill Heating & Ventilating Co., 139 Pearl St., Boston. Noted Sept. 28.

N. Y., Buffalo—The Central Park Methodist Episcopal Church has awarded the contract for a 3 story, 150 x 180 ft. church on Morris and Wesley Sts., to Robert E. Williams, Iroquois Bldg., at $350,000.

N. Y., New York—The Tivoli Amusement Co., c/o Arena Theatre, 40th St. and 8th Ave., will build a theatre and office building, including a steam heating system on 50th St. and 8th Ave. About $500,000. Work will be done by day labor.

Md., Baltimore—The American Ice Co., Calvert Bldg., has awarded the contract for a 33 x 99 x 82 ft. ice storage building, on Montford Ave. near Chase St., to the G. A. Fuller Co., American Bldg., at $200,000.

O., Cleveland—The Fisher Body Co., Oakland and Piquette Sts., has awarded the contract for a 1 story, 95 x 114 ft. power house, on East 140th St. and Coit Rd., to the Thompson Starrett Co., Perry Payne Bldg., at $200,000.

Ind., Indianapolis—The Westinghouse Lamp Co., 165 Bway, New York City, has awarded the contract for a manufacturing plant, including a steam heating system, here, to D. P. Robinson, 125 East 46th St., New York City, at $500,000. Noted Aug. 31.

Ill., Clearing—The Hamler Boiler & Tank Co., 3906 South Halsted St., Chicago, has awarded the contract for a 1 and 2 story, 100 x 300 ft. factory, including a steam heating system, on 66th St. and 60th Ave., to W. J. Nelson, 1537 West 63d St., Chicago, at $500,000.

Ia., Wapello—F. G. Wright, Co. Aud., has awarded the contract for a drainage pumping plant, including 2 centrifugal pumps of equal capacity driven by oil engines, to Layton Constr. Co., Muscatine, at $76,085. Noted Sept. 14.

Minn., Minneapolis—The Bd. Educ., c/o G. F. Womrath, Supt., City Hall, has awarded the contract for a heating and ventilating system in the Clinton School addition to Bjorkman Bros., 712 South 10th St., at $41,399. Noted Oct. 5.

Minn., St. Paul—The city has awarded the contract for the installation of a vertical triplex motor driven pump to have a 350 gal. capacity per minute against a total 150 ft. head, single acting, belt for 150 lb. pressure, to the Robinson, Cary & Sands Co., 4th and Wacouta Sts., at $3,510.

S. D., Sioux Falls—The city has awarded the contract for a motor house and well to Fauenust Bros. at $16,600.

Mo., Kansas City—J. A. Wetmore, Supervising Archt., Treasury Dept., Wash., D. C., has awarded the contract for the complete installation of outside steam service here to the MacMahon Plumbing & Heating Co., 1329 Oak St., at $10,476.

Ont., Ottawa—Dey Bros., Laurier Ave., W., have awarded the contract to the Dominion Bridge Co., Imperial Life Bldg., Toronto, for steel work in connection with their new artificial ice rink. A plant for manufacturing and maintaining artificial ice surface and a steam heating system will be installed.

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